TECHNOLOGY DEPT.

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by G. B. PARTRIDGE.

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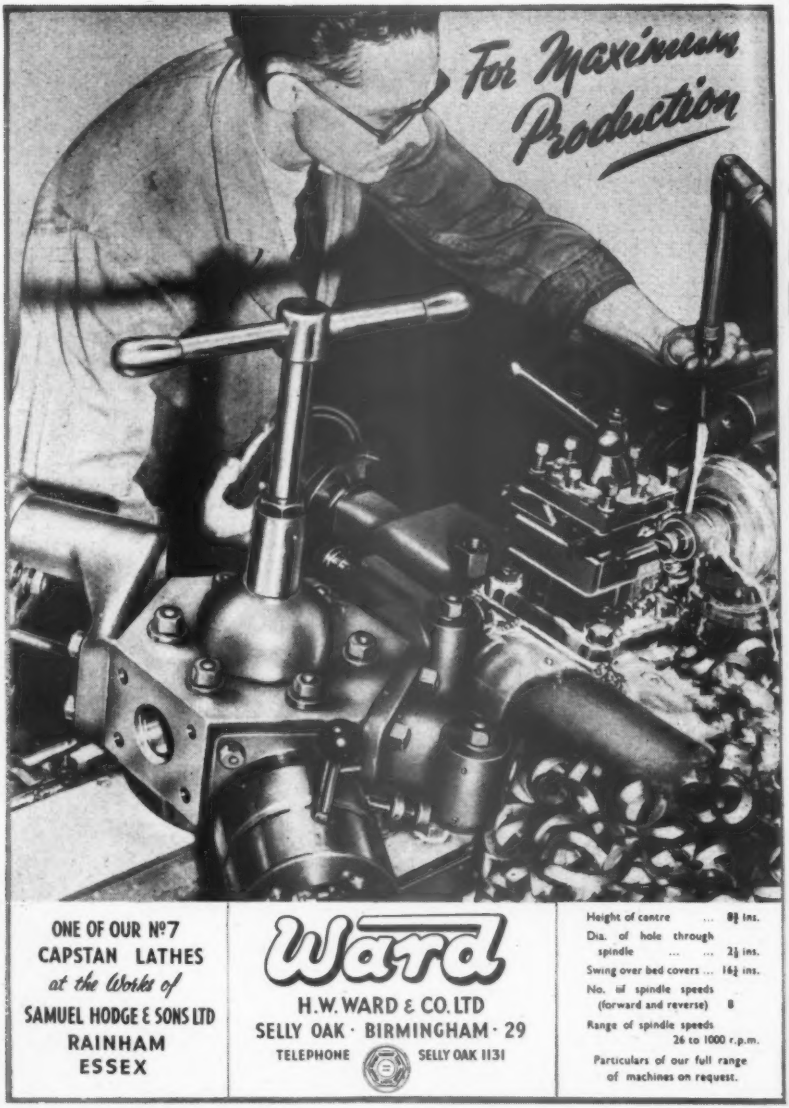

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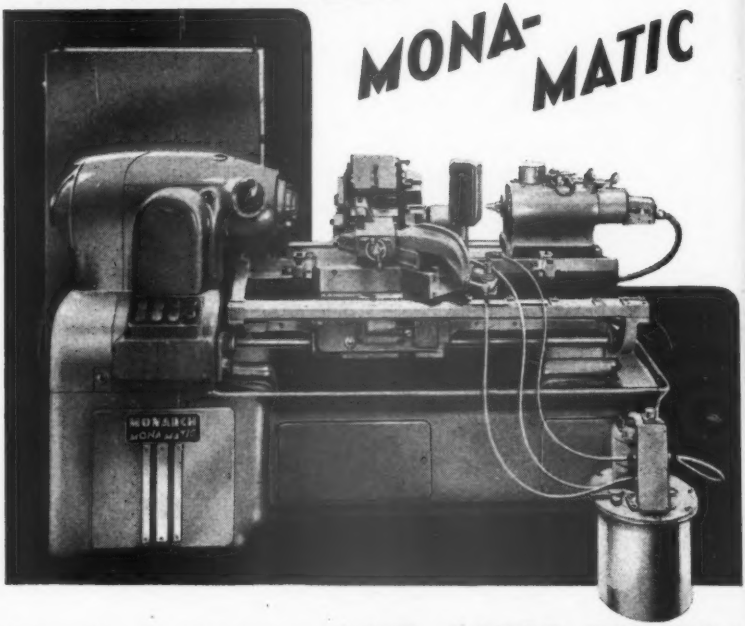

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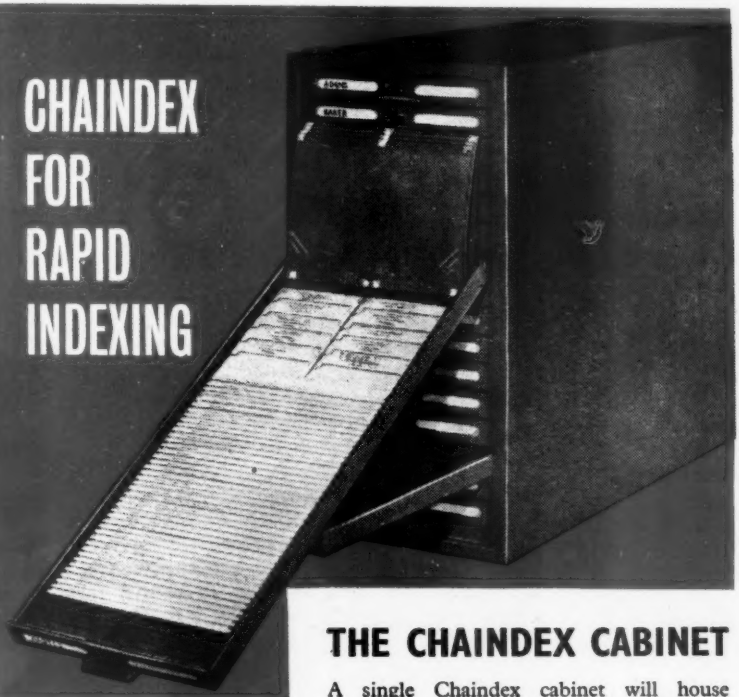

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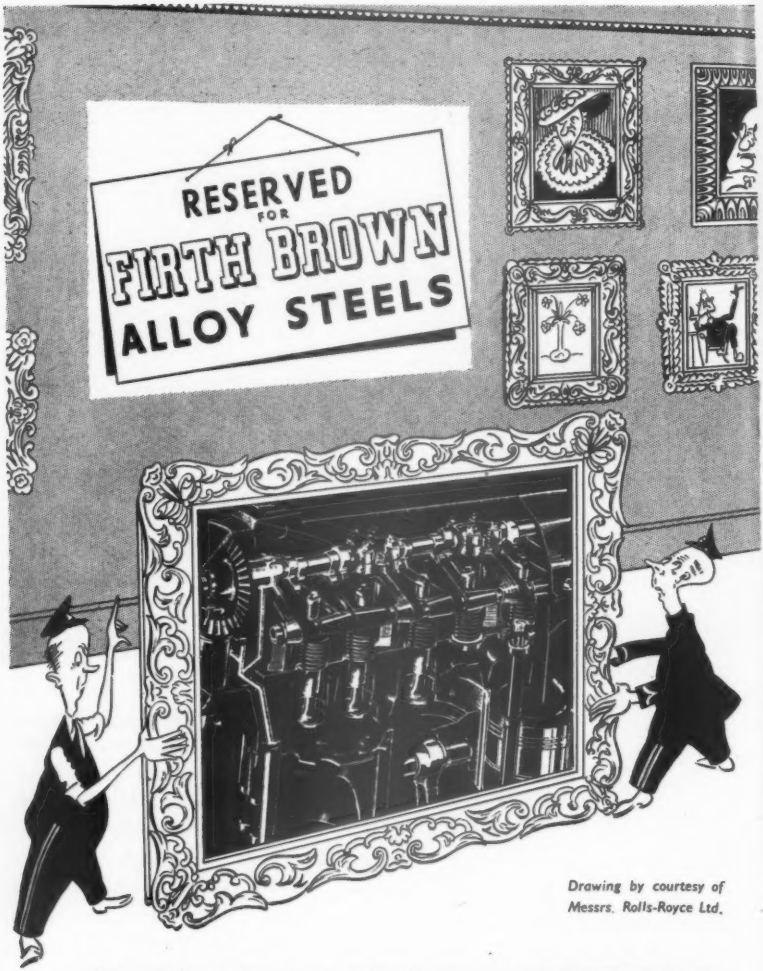

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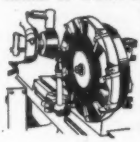

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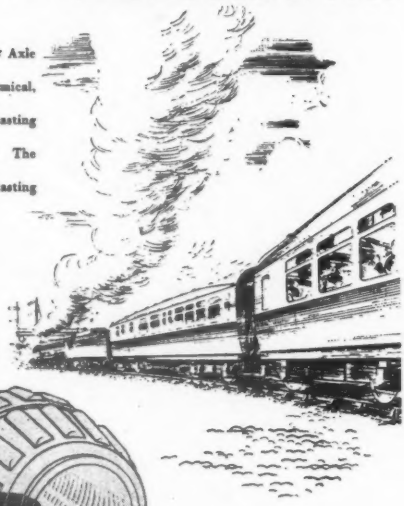

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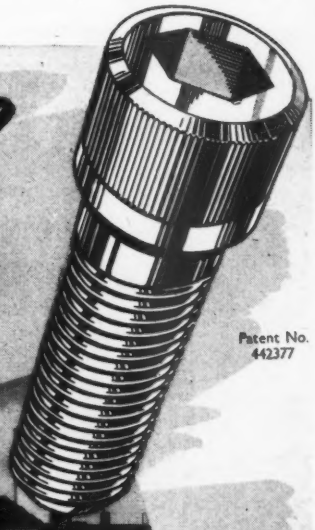

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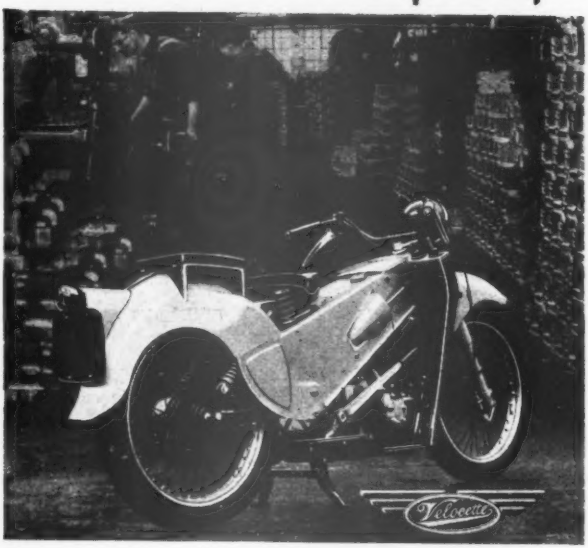

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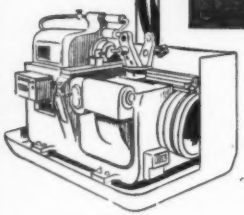

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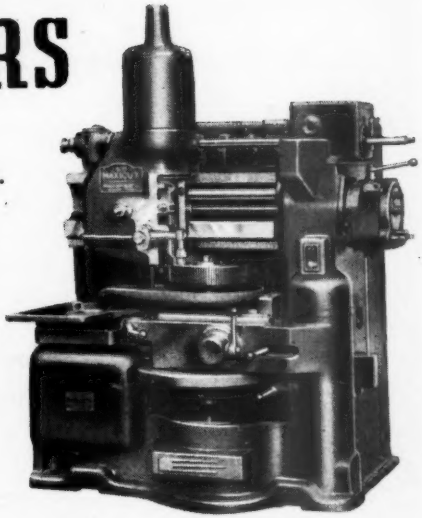

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INSTITUTION NOTES

July, 1949

MEETING OF COUNCIL

The next meeting of Council will be held on Thursday, July 21st, 1949, at 36, Portman Square, London, W.1. at 11 a.m.

FACTORY MANAGEMENT AND MAINTENANCE

The Institution has been asked, by a well-known London publishing house, for assistance in finding authors to contribute to a proposed new series of publications on " Factory Management and Maintenance."

It is intended that the subject should be broken down into four main sub-sections :

(1) Factory Layout

(2) Production

(3) Maintenance

(4) Labour Management and Industrial Relations,

and the type of author required, in each case, is a man who has had considerable first-hand experience on the actual job.

If any qualified members are willing to have their names submitted in connection with this work, it would be appreciated if they would communicate with Head Office as soon as possible. Letters should be addressed to the Technical & Publications Dept.

It will of course be realised that in the event of introductions being effected, the Institution cannot accept any responsibility in respect of the matter and the terms arranged.

TECHNICAL EDUCATION

A full time Post-Graduate and Post-Advanced course in Engineering Metrology (Technical Measurement), extending over one academic year, will be provided in the Manchester Municipal College of Technology (Principal J. E. Myers, O.B.E., J.P., D.Sc., A.R.I.C.), commencing in October, 1949.

The course will be repeated in subsequent sessions and will deal with the science and practice of measurement in relation to engineering products and the machine tools employed in production, and to industrial and scientific research. Facilities for Post-Graduate research will also be provided.

Candidates for admission to the course will require to possess a University degree in Engineering, a Higher National Certificate in Production Engineering or Mechanical Engineering, or other suitable qualifications.

In the first year, the number of admissions will be limited to a maximum of about twelve, and information will be forwarded to intending students and others who complete and return an enquiry form obtainable from the College.

NEWS OF MEMBERS

Mr. G. W. E. Godden, A.M.I.P.E., has been appointed Chief Inspector to K.L.G. Sparking Plugs, Ltd., London.

Mr. N. F. Hale, Int.A.M.I.P.E., has joined Courtaulds, Ltd., Coventry, as Planning and Time Study Engineer in the Bakelite Factory.

Mr. R. Pile, Int.A.M.I.P.E., is now Planning and Time Study Engineer with Avery-Hardoll, Ltd., Tolworth, Surrey, a subsidiary company of the W. & T. Avery organisation.

Mr. J. T. Radford, A.M.I.P.E. has been appointed Chief Inspector at the Telecommunications Research Establishment, Defford.

Mr. R. V. Rider, Grad.I.P.E., has been appointed Research Engineer with the Production Engineering Research Association of Great Britain.

Mr. M. P. J. Smith, A.M.I.P.E., has recently arrived in England from Canada, to take up the position of Works Manager to the Emco Brass Mfg. Co. Ltd., Croydon, a subsidiary company of the Empire Brass Mfg. Co. Ltd., London, Ontario, Canada.

Mr. E. L. Stead, A.M.I.P.E., is now Designer Technician with Anderton Springs, Ltd., Bingley, Yorks.

Mr. Percy White, A.M.I.P.E., is now Chief Draughtsman to J. Lyons & Co. Ltd., London.

Mr. Harry Wright, Int.A.M.I.P.E., has accepted an appointment with the Chloride Electrical Storage Co., Manchester, as Chief Development Engineer.

VISITORS FROM ABROAD Mr. J. B. Robinson, M.I.P.E., of the Sydney Section, is at present visiting the United States and the United Kingdom in order to study coal mechanisation and general engineering plant maintenance. Mr. Robinson, who was educated and learned the machine tool trade in the Manchester district, settled in Australia in 1919 and is now Master Mechanic with Australian Iron and Steel, Ltd., Port Kembla, New South Wales.

Mr. J. B. Robinson

Mr. H. G. Sutton, M.I.P.E., of the Melbourne Section, is visiting the United Kingdom and subsequently the Continent, the United States and Canada, in order to study the latest trends in design and manufacturing conditions. Mr. Sutton is Joint Managing Director of The Sutton Tool & Gauge Manufacturing Co. Pty. Ltd., Northcote, 16, Victoria.

EDUCATIONAL APPOINTMENT The Scunthorpe Technical School, Scunthorpe, requires a full-time lecturer principally for Science and Mathematics in Craft Courses in Mechanical Engineering (e.g. Machine Shop Engineering) to City and Guilds Intermediate standard. A Degree in engineering or equivalent qualifications are desirable, and experience in industry is essential. Further particulars may be obtained from the Principal.

BOOKS RECEIVED "Engineering Tolerances" by H. G. Conway. Sir Isaac Pitman & Sons, Ltd., London. Price 30/- net.

"Business Charts" by T. G. Rose, M.I.P.E. Sir Isaac Pitman & Sons, Ltd., London. Price 18/- net.

"Management for Production." British Institute of Management. Price 2/6 net.

"Electric Power Engineering in Germany, 1939/1945." B.I.O.S. Overall Report No. 11. H.M.S.O. Price 1/3 net.

"Ferrous Materials for the Engineer" (Industrial Text-book Series, No. 14) by Reginald Fox, A. Met(Sheff)., A.I.M. Charles Griffin & Co. Ltd. Price 12/6 net.

ISSUE OF JOURNAL TO NEW MEMBERS Owing to the fact that output has to be adjusted to meet requirements, and in order to avoid carrying heavy stocks, it has been decided that the Journal will only be issued to new Members from the date they join the Institution.

IMPORTANT In order that the Journal may be despatched on time, it is essential that copy should reach the Head Office of the Institution not later than 40 days prior to the date of issue, which is the first of each month.

Mr. T. A. WESTALL

The Institution wishes to correct the false impression conveyed by a statement inadvertently published in the biography of Mr. T. A. Westall, M.I.P.E., in the June issue of the Journal.

It would appear, from the statement in question, that Mr. Westall became Assistant Works Manager of Butterworth and Dickinson, Ltd., of Burnley, after holding the position of Works Manager. This is incorrect, and it should be made clear that Mr. Westall left Butterworth and Dickinson, Ltd., as Works Manager, to become Assistant Works Manager of Joseph Lucas, of Burnley.

SECTION MEETING

The following meeting has been arranged to take place in July, 1949. Where full details are not given, these have not been received at the time of going to press.

July

7th COVENTRY SECTION. A visit has been arranged to Stratford Theatre to see a performance of "Cymbeline," preceded by a dinner. The party will assemble at Pool Meadow at 5.30 p.m.

MAGNESIUM CASTINGS AID BRITAIN'S INDUSTRIAL RECOVERY

by G. B. PARTRIDGE,

Presented to the Southern Section of the Institution, September 22nd, 1948.

WHAT is magnesium? It occurs abundantly in nature mainly in the form of its salts $MgCl_2$ and MgCo3 and these salts form the raw material from which the metal is extracted. Pure magnesium is a silvery white metal with a coarse grain, is relatively weak but possesses the distinction of being the lightest commercial metal available to-day; its specific gravity is 1.74, which means that it is $\frac{1}{4}$ the weight of steel and $\frac{2}{3}$ the weight of aluminium. It forms the basis of the well known "Elektron" series of alloys which are being increasingly used with success in the various branches of engineering.

EXTRACTION

Although America, Canada and Germany are large scale producers of magnesium, the extraction in this country has a special significance for us all to-day because it is entirely English made and we can proudly write across our industrial life "No Dollars for Magnesium." I am sure that no one will deny the importance of this vital fact when we are beset by so many trials and shortages.

Seawater contains small amounts of magnesium as the chloride salt, and the metal is produced by the reaction of seawater with Derbyshire Dolomite limestone. Let us dwell for a moment on the significance of this small amount of magnesium contained in seawater. Dr. Dow, of the Dow Chemical Co., has stated that every cubic mile of sea contains 9 billion lbs. or 4,017,919 tons of magnesium metal. As the seas of the world are of the order of 300 million cubic miles, our raw material supplies are fairly certain.

The magnesium oxide formed by the above process is calcined and chlorinated by passing chlorine gas over the MgO at 900° C., whereupon liquid $MgCl_2$ is formed which is tapped off from time to time into electrolytic cells. The electrolytic process is going on continuously and when sufficient globules of metal are formed they are ladled out and the cell replenished with further $MgCl_2$ from the chlorinator. The crude magnesium is now run down in 2 ton pots, the necessary elements added to form the Elektron alloys and after cleaning with fluxes, the pot is removed to a continuous casting machine where ingots of about 5 lbs. in weight are poured.

The Institution of Production Engineers does not accept responsibility for any statements made or opinions expressed in any papers published in the Journal of the Institution.

THE ALLOYS

The Elektron Magnesium alloys are not, as some have supposed, another form of aluminium but consist basically of magnesium (from 90% to 96%) with which are alloyed aluminium (from 3% to 10%) zinc (.5% to 1.0%) and manganese (.25%). The object of these additions is to obtain high strength materials which can function successfully in various engineering applications. The inherent low specific gravity gives these alloys very attractive strength/weight ratios. The major alloy in commercial use to-day contains 8.5% aluminium, .6% zinc, .2% manganese (remainder magnesium) and its average mechanical properties in the 'as cast' state are 9.5 tons sq. in. and 3% elongation; after suitable heat treatment these values are increased to 15 tons sq. in. and 7% elongation.

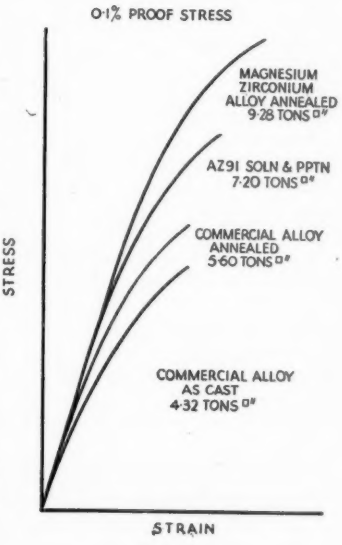

0·1% PROOF STRESS
MAGNESIUM ZIRCONIUM ALLOY ANNEALED 9·28 TONS □"
AZ91 SOLN & PPTN 7·20 TONS □"
COMMERCIAL ALLOY ANNEALED 5·60 TONS □"
COMMERCIAL ALLOY AS CAST 4·32 TONS □"
STRESS
STRAIN

FIG. 1.

Special mention must be made of the recently developed magnesium alloy containing zirconium, whose outstanding characteristics are the considerably improved 0.1% Proof Stress, and much better corrosion resistance; this alloy has an extremely fine grain and has taken years of persistent effort to perfect.

CASTINGS MANUFACTURE

Magnesium alloys are sand cast, die cast and pressure die cast but as the greatest production goes into sand castings, it is these latter which we shall talk about tonight.

Before proceeding with the actual description of manufacture, however, it is as well to recall to mind the chemical behaviour of magnesium; the matter following will then be understood much more simply.

As soon as magnesium reaches its melting point it takes fire in air and will also decompose water vapour; it is clear therefore that as soon as the liquid metal leaves its protective flux cover as it is poured from the pot, this burning will occur unless suitable precautions are observed. These precautions take the form of

additions of sulphur and boric acid to the moulding sand ; unfortunately, however, as the sulphur burns it releases fumes of SO_2 which render the atmosphere somewhat pungent and difficult to work in. This has led to the development of special foundry buildings.

SANDS

Foundry moulding sands consist of silica grains bonded together with clay to give the strength necessary to form the intricate shapes demanded by designers in the name of castings. Magnesium moulding sands are the same but contain in addition the inhibitors sulphur and boric acid just referred to. Foundry sands are divided into two classes (a) natural sands (b) synthetic sands, and whilst both sorts have their champions, it must be admitted that the advantages of synthetic sands outweigh their high initial cost. The fundamental difference is that whereas natural sand is used direct from the quarry, virtually without change (except for inhibitor additions), synthetic sand is made from selected pure silica grains bonded with clay of one's own choice (usually Bentonite or Fulbond). The properties and characteristics of natural sands are already determined in their natural state and can only be controlled within narrow limits, but with synthetics definite properties are obtained according to the mixture made. The qualities mostly demanded of sands for magnesium foundry work are ;

(1) low moisture contents to prevent any chemical reaction.
(2) good venting power or permeability to enable the mould gases to escape rapidly.
(3) low dry strength cores which collapse easily and do not hinder the contraction of the cooling metal.

The reasons why the inhibitors prevent the reaction of magnesium with air and water are not perfectly clear, but it seems probable that as the sulphur burns it uses up all the available oxygen, thus surrounding the metal with an inert atmosphere ; the boric acid coats the sand grains, prevents silica reactions and also protects the clay.

MOULD GATING SYSTEMS

Although very large scale production was obtained during the war, magnesium foundries in this country even where mechanised have not yet attained the position held by the iron foundry industry, for instance, such as in the motor car trade ; that is, they still largely belong to the jobbing class ; however by virtue of this fact they take on a very wide scope of work, ranging from castings weighing a few ounces to the big fellows of 200 lbs. and more and a magnesium casting of this weight is some job. The quantities off a particular pattern determine whether it shall be plated or not and if this is

decided upon, the plated pattern is usually worked on a moulding machine which is a device which replaces much of the brawn desired of the moulder and considerably speeds up and therefore cheapens the job.

As is usual in many foundries, a specially milled sand is sieved upon the pattern face, followed by floor or knocked out sand which then fills the moulding box ; these sands are known respectively as facing and backing, the idea being to ensure that only first quality sand comes into contact with the metal. However, by suitable arrangements the whole sand system is sometimes treated so that it virtually becomes facing quality ; whilst this is initially more expensive the cost is absorbed in the quicker turn out of castings inevitably resulting from such a procedure.

Previous remarks have drawn attention to the extreme chemical reactivity of magnesium and this factor is reflected in the method used to gate and feed Elektron castings. To succeed the following conditions have to be fulfilled : (a) the formation of oxide skins and risk of moisture attack must be avoided ; (b) the entry of the metal into the mould must be fast but smooth ; (c) large risers must be provided to give adequate feeding ; (d) solidification must be as rapid as possible.

The usual entry of the metal into the mould proper is through bottom gates after it has descended rectangular channels and flowed through a suitable runner system. A typical runner shape is

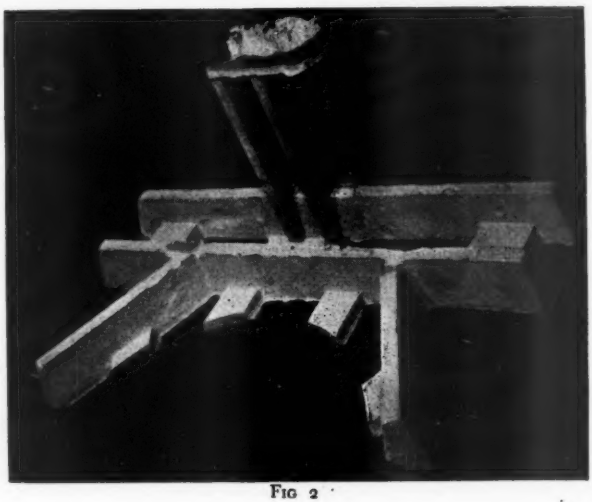


FIG 2

illustrated and this design enables oxides and dross to be caught in the upper portion allowing the clean metal to enter below. There is an unfortunate aspect of this bottom running inasmuch that the heat is at the wrong end of the casting ; this being so, feeding is all the more difficult to apply ; attempts to minimise this difficulty have resulted in the application of a second set of gates entering the mould at a higher level. This principle is carried a stage further in the use of the slit gate which enables successive layers of hot metal to build up and so give ideal progressive solidification conditions. Large risers are the rule when making magnesium castings to provide essential feed, but where these are difficult to apply, such as for heavy bosses set fairly deep in the casting, chills are used in the usual manner as when using the more conventional foundry metals.

METAL PREPARATION

Oil or gas fired furnaces are mainly used for the melting of the Elektron alloys, the metal being actually contained in a pressed mild steel pot. The melting process is as follows : Virgin ingot is placed in the pot with as much scrap as possible and heating commenced ; when the metal begins to melt, light dustings of a low melting point flux are applied to prevent any burning from taking place. As melting proceeds more scrap is added and any local burning quenched by

FIG. 3 (a)

light dustings of flux ; when the level of liquid metal reaches to within about 3 inches of the rim of the pot, additions of scrap cease and a layer of refining flux is sprinkled on the surface of the melt.

The temperature is gradually rising and as it reaches about 740° C. the refining or " washing " process commences ; the flux cover is stirred vigorously with a bent steel tube or rod, using a rotary motion, until it sinks through the melt carrying all oxides and impurities and the globules of the more fluid type flux down to the

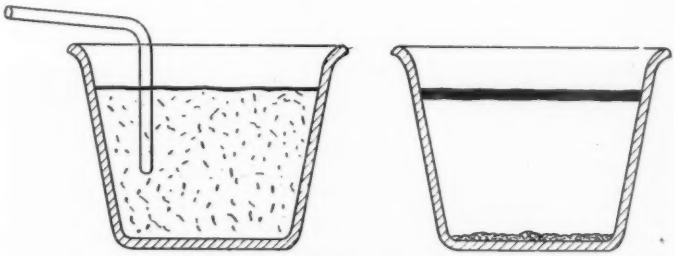


FIG. 3 (b)

bottom of the pot. Further protection is now afforded to the liquid metal by the application of another layer of refining flux which forms a firm crust and remains untouched until the metal is ready to pour. (Figures 3(a) and 3(b)).

GRAIN REFINEMENT

It is very important to mention the desirability of magnesium castings possessing a fine grain, as it is only in this condition that their superior mechanical properties are achieved. This brings us to the grain refining procedure which can be carried out in two distinctly different ways : (a) superheating (b) carbon innoculation. The former has been in use almost since the inception of magnesium founding, and consists of applying heat to the melt over and above that required to pour satisfactory castings : temperatures of about 900° C. are common and by virtūe of this excess heat the process is called superheating ; it follows immediately after the washing process. The carbon innoculation is a very modern discovery and is carried out by plunging carbonaceous compounds into the melt and allowing the released CO_2 gas to bubble through the metal ; this process however takes place before the washing just described, so that no inclusions will be stirred up into the body of the melt and into any subsequent castings. This carbon process has almost completely superseded the older superheating as it is easier and offers other economical advantages ; there is not time now to attempt to

discourse upon the possible reasons for this grain refining effect, which still remain obscure even among the most learned scientific bodies.

POURING THE CASTINGS

For the purpose of pouring the pot is removed from the furnace and placed in a suitable holder, which can be slung on to the overhead crane ; pouring temperatures usually range from 740° C.-800° C., depending upon

FIG. 4.

the section thickness of the casting, and the metal is poured as soon as the desired temperature is reached, the following procedure being adopted. The pouring spout and adjacent edges of the pot are cleared of encrusted flux and the flux cover pushed away from the pot lip with a skimmer ; pouring commences at once, the stream of molten metal being protected from oxidation by the immediate dusting of flowers of sulphur. (Figure 4.)

If the castings are subject to A.I.D. inspection, test bars are cast just prior to the pouring of the production moulds.

Apart from the question of fine grain there is another factor which has to be taken into account when magnesium is being melted, and that is the possibility of gas absorption. The use of damp fluxes and corroded or indifferent scrap can introduce hydrogen into the metal, which has a weakening effect upon the finished casting. Good melting practice takes care of this angle.

FETTLING

After knocking out and decoring, the castings are fettled by using all the well known modern equipment, band saws for removal of runners and risers, pneumatic chisels for the trimming of flash etc. ; risers of large cross section are sometimes parted off in preference to sawing and it is worth mentioning here that in America the risers are sometimes left intact until the first machining operation, when they are removed at the same time. All castings are shot blasted as this process reveals any hidden defects, thus making the operation an important preparation for routine inspection.

INSPECTION

Visual inspection of the castings takes place first and this is followed by X-Ray inspection when requested. (Figures 5 (a) and 5 (b).) The foundry use X-Ray for control and development purposes but it is only applied as a final inspection tool where the expense incurred is justifiable. As an alternative to X-Ray a casting is sometimes deliberately crushed up and the fractures examined for signs of unsoundness ; this is done because intricate castings are sometimes difficult to radiograph with any certainty. It will be realised that dimensional inspection by the usual means will take place as a matter of course for sample castings and if thought necessary, certain measures may be introduced as a routine check up.

HEAT TREATMENT

Substantial increase in strength is obtained when certain magnesium alloys are given a heat treatment ; this consists of a soak for 24 hours at a temperature of about 420° C. and is called solution heat treatment. There is a low temperature treatment (250° C.) which is very useful for the

FIG. 5 (a)

FIG. 5 (b)

FIG. 6

relief of internal stresses, and also an age hardening treatment which develops maximum hardness and proof stress.

The most popular type of furnace for carrying out solution heat treatment is the electrically heated pit furnace with forced air circulation, and during the War hundreds of tons of magnesium castings were treated in this way. (Figure 6.) The strength of magnesium castings at temperatures of 400° C. is low and unless care is taken, any overhanging parts of the casting will distort. For this reason the racks upon which the castings are placed are machined dead flat. Heating masses of magnesium in air is a ticklish business, so to prevent any firing from occurring a sulphur dioxide atmosphere is maintained during the heating period. The lower temperature treatments are usually carried out in gas fired stoves, these being quite convenient for the purpose and no protective atmosphere is necessary.

Before leaving the works all castings are given a protective chemical dip against corrosion, which also serves as a very good paint base.

DEFECTS

Do magnesium castings have defects? That is easy enough to answer—they do, but reflection upon the chemical activity of the material will show that because of this vigorous activation most of the defects are trapped before they leave the foundry. This means that the machinist can set up his magnesium casting with complete confidence, knowing that no troubles lie under the skin as so often happens with other metals.

MICRO-POROSITY

The defect which has received most publicity is known as micro-porosity or micro-shrinkage and this occurs in most magnesium castings. It is porosity which can only be defined with a microscope and consists of voids between the individual grains of the metal. The weakening effect of this porosity is only serious when it occurs in a vital part of the casting, otherwise a small amount is tolerated without fear. In general, good metallurgical and foundry practice will keep micro-porous castings to a minimum.

SURFACE DEFECTS

Oxidation or actual burning of the metal occurs when the inhibitor in the sand is below strength and this defect appears as ragged cavities on the surface of the casting. Scum is the term given to oxides and nitrides which lodge either in or on the surface of the casting and the presence of these "burnt metal skins" lower the mechanical properties slightly.

These and other defects such as blows, sinks and draws which can occur in magnesium castings manufacture are obviated by the intelligent application of experience on the part of the foundry

and laboratory, but designers are still very keen on cooking up some devilish shapes which certainly require all our ingenuity before success in their manufacture is achieved.

APPLICATION

We can now consider some of the applications of magnesium castings, and in so doing review their design characteristics and general qualities.

The first thing to remember is that magnesium is a relatively new engineering material and realisation of this fact reveals that its mode of application divides broadly into two classes :—

(1) Specific application where its properties make it the ideal material for the job.

(2) Replacement of parts previously made in other materials because magnesium was not available when the original casting was designed.

PRICE

I have noticed when attending lectures that economics are frequently ignored as being beneath the pure science of the particular subject, but to me that seems a very narrow and inadequate view. I propose therefore to bring out into the open this vexed question of cost, so that the matter to follow will not be treated as merely of academic interest.

On a volume basis the present price of magnesium is about the same or even less than many of the specified virgin aluminium alloys, and the magnesium frequently has superior properties. To help overcome the slightly higher overhead costs met with in the magnesium foundry, it is essential for potential customers to discuss their requirements with the founders at a very early stage, bearing in mind that the following decide the final cost : 1. Simplicity of design of the part ; 2. Perfect pattern equipment which decides : 3 The speed of production. By simplicity I mean the omission of frills which do little else but increase the cost ; magnesium founders are no strangers to necessary intricacy of shape.

It will be realised that although the material is cast in competition with many aluminium applications and with cast iron, the position is more difficult and the cast iron part will usually be cheaper piece for piece. But what of the important factors (a) manhandling and (b) machining ? Full appreciation of a magnesium casting can only be made by viewing a job in its entirety, taking into account the lower transport and handling charges and the much reduced machining costs. The metal has also an appreciable scrap value.

FUNDAMENTAL CHARACTERISTICS

All argument or discussion on magnesium alloys must take into account the ultra-light weight of the material, $\frac{2}{3}$ that of aluminium and $\frac{1}{4}$ that of steel This elementary fact means that for a given weight magnesium will

occupy a much larger volume than most other materials ; this characteristic is most important and results in magnesium successfully resisting buckling and bending forces which depend upon the thickness of a material. The maximum advantage that can be achieved by the substitution of magnesium for other materials is when an increase in cross sectional dimension can be tolerated. The extra sturdiness which automatically follows from the use of a more sturdy component is very useful, because it endows the part with extra ability to take punishment, i.e. accidental distortion or stresses may be imposed which cannot be calculated beforehand and are more likely to be successfully resisted. Magnesium alloy is valuable in the case of reciprocating parts where the self-destructive action of the part increases in direct proportion to its own weight.

MODULUS OF ELASTICITY This value is 6.5 x 10^6 lbs/sq. in. for the magnesium alloys and by direct comparison with other alloys is low. It must be considered when designing in magnesium and although the low specific gravity will provide compensation by allowing increased section, and therefore stiffness, this should be checked carefully if maximum rigidity is essential.

RESILIENCE This is the capacity to absorb shock in the elastic range and the magnesium alloys possess a high resilience. The most common example of the capabilities of magnesium to withstand shock is the case of aircraft landing wheels. A logical development of the aircraft wheel is the road wheel, and satisfactory data is already being obtained about the performance of the material in this sphere.

DAMPING CAPACITY This property is possessed to a very high degree by the magnesium alloys and is expressed as the capacity of a material to absorb vibrational energy and change it into another less harmful form. The classical but exaggerated argument on damping capacity is that repetitive synchronous blows by a peashooter on a skyscraper will eventually induce self-destructive vibration ; with magnesium this tendency is considerably lessened.

FATIGUE STRENGTH This is of great importance in applications which are subject to alternative stresses, such as engine parts. In general magnesium castings have good fatigue resistance but in this connection it is very important to see that castings design and machining practice is directed to the elimination of sharp corners etc., to avoid undesirable stress concentration effects. The provision of adequate fillets, rounding of corners, beading of holes should be regarded as axiomatic for all good engineering design, but the importance of these safeguards should be emphasised when dealing with magnesium.

BEARING PROPERTIES Lightly loaded bearings are an accomplished fact in magnesium, examples being aero-engine camshaft bearings, small electric motors and the like. Heavier loads, however, require bearing liners or cast-in inserts which should be "keyed" well and be of generous dimensions. The fully aged alloy will give a Brinell of about 85.

DIMENSIONAL CHANGE Some small dimensional change can take place in magnesium alloys as with most other materials and if extreme accuracy is essential, the material should be supplied in one of the heat treated conditions.

To avoid dimensional changes in some jobs it may be necessary to rough machine and leave a few days before completion.

MACHINING The properties of magnesium alloys in this respect are truly phenomenal and it is unfortunate that machines with the necessary high speeds to take full advantage of this fact are not in common use. A calculated saving of 50% compared with cast iron has been claimed, the general advantages being :

(a) longer tool life.

(b) less power required.

(c) ease of handling.

(d) greatly increased rate of machining speed.

There are very definite but simple directions for the successful machining of magnesium castings and if they are followed, success is automatic. The following are the most important :

(a) Owing to the high coefficient of thermal expansion coupled with the low heat capacity of magnesium, these factors act together to distort the piece dimensionally, therefore the work must be kept cool and compressed air directed on it at the cutting edge of the tool is a very convenient means.

(b) The low modulus will allow of easy deflection and clamping of the work should therefore be done very carefully.

(c) Heavy cuts producing large chips are the rule but a light finishing cut can be permitted.

(d) Tools must be kept sharp and care taken to see that no rubbing of the work occurs.

CORROSION For many years the "bogey" of corrosion has dogged our footsteps but we have hopes that slowly but surely it is being lived down. The facts are that bare magnesium alloy will stand up to inland atmospheres better than iron or steel, a superficial layer of oxide being the only sign of

attack. No intercrystalline corrosion occurs, so the body of the material remains sound. With seawater, the story is different and corrosion is drastic as it also is with other materials. In general, acid conditions favour attack and alkaline conditions prevent it, but the whole question should be thoroughly ventilated with the suppliers who will be pleased to give the necessary advice for any given application. Whilst the above remarks apply to unprotected metal, it must not be forgotten that all castings are protectively dipped which provides an excellent paint base, priming being done with a coat of zinc chromate after which various paints or low temperature enamels can be applied.

FURNITURE PRODUCTION

by R. E. HARRISON, B.Com.

Presented to the Glasgow Section of the Institution, December 16th, 1948.

In introducing a paper on a subject so broad as " Furniture Production," it is perhaps essential first to indicate briefly the nature of the industry and its products and the widely different types of production to be found in it, before turning to the particular aspects which are likely to be of most interest to members of this Institution.

Before the war, very little information was available about the industry, but the Working Party appointed by the Board of Trade in 1945 issued, in 1946, a report* which contains much statistical information which had never previously been collected, and it is largely from this source that we are now able to draw a broad picture of the furniture industry proper—at least, as it was in 1938. The description " furniture industry proper " covers the manufacture of domestic furniture mainly made of wood, and it includes upholstery but excludes the many establishments producing joinery, shop and office fittings on the one hand, and furniture principally made of metal, glass and plastic materials on the other. Much of the subsequent comment in this paper would, however, be applicable to the manufacture of joinery and wooden shop and office fittings.

PRE-WAR POSITION

The industry in 1938 employed, in establishments of not less than eleven employees, some 76,000 workpeople, and it had grown to this size from the level of some 45,000 workpeople in 1924. This growth was the outcome of the great extension of hire-purchase facilities and of the development of furniture to sell at much lower prices than had been common prior to 1924. It was estimated that in 1938 there were approximately 1,000 establishments in the industry employing more than ten persons and some 1,500 establishments which employed ten or fewer. Of the 1,000 firms which employed more than ten, no less than 577 employed less than 50 persons and a further 344 employed less than 200. The big producers were limited to 56 concerns which employed between 200 and 400, and 20 which employed more than 400. The industry is therefore characterised by having a very much larger proportion of small producers than the average for the industry of the country as a whole.

Apart from this high proportion of small producers, the industry

* *Board of Trade Working Party Reports, FURNITURE (H.M.S.O.), Chap. III.*

is also characterised by the great diversity in production methods. In the small units, production methods are in many cases not very far developed from the days of the hand craftsmen pure and simple. Very little plant is in use, and specialisation between the various production processes is not carried out to any great extent. There is evidence, according to the Working Party Report, that between the wars firms of this type were finding it increasingly difficult to maintain themselves, but that they were able to do so at all is somewhat striking. This survival of the small producer is probably due, to a large extent, to the fashion element of furniture on the one hand, and to the very wide price range in the industry on the other.

In the medium-size establishment, plant and equipment and specialisation of process have developed to a considerable extent, separation of the machine shop from cabinet making is complete, and the number of operations performed by hand has been very substantially reduced. It is, however, generally true to say that production methods still derive from the old traditional craft of cabinet making, and this type of production has come to be referred to nowadays as "machine-assisted production." It is not until we consider the larger producers, together with such of the smaller ones as have been able to achieve a high degree of specialisation in one product, that we find any significant developments in the technique of furniture production. Gradually, between the wars, these producers were initiating production on lines similar to those already generally adopted in the engineering industry, and the production engineer (though he was seldom so described) and the techniques of his calling began to appear in the furniture industry. Many unusual problems were met with in this development, and it is to a consideration of these, and of the methods by which solutions to them are being reached, that the latter part of this paper is devoted. Before proceeding to this consideration, however, we should briefly describe the principal raw materials of the industry and the various basic production processes which have to be carried out. As it will not, within the limits of this paper, be possible to do justice to both the upholstery and cabinet making sides of the industry, it is proposed to confine these descriptions and subsequent matter to the manufacture of cabinet furniture, which represents approximately 70 per cent. of the gross value of the production of the industry.

RAW MATERIALS

The chief raw material of cabinet making is, of course, wood of various kinds and in various forms. It is received in three chief states—solid, laminated and veneer.

Solid wood, which is principally hardwood, is usually bought in the form of lumber ; that is, in boards nominally sawn to a required

thickness. Before the war, practically all the hardwood used in the industry was imported, and it was received with both edges sawn square and approximately parallel. This imported lumber was bought by grades, but the efficiency of the system of grading and, in fact, the actual system of grading itself varied widely between different countries of origin and even between shippers in the same country. It was, however, generally possible to buy a top grade of lumber which was reasonably but not entirely free of defects, but in the lower grades the variation in quality was often very great. Lumber could not be bought, however—except in special cases—to any particular length or width and the furniture manufacturer had to accept parcels which included a wide variety of sizes. Typical hardwood specifications were, for example : 9 to 16 feet long, 6 to 11 inches wide, or, at a lower price, 5 to 9 feet long and 4 to 7 inches wide. The imported lumber was usually received by the furniture manufacturer after it had undergone a preliminary drying process in the country of origin to a state regarded as freight dry, that is, approximately 20 to 25 per cent. moisture content. During the war years, and indeed still to-day, a very large proportion of the hardwood used by the industry has been of home grown origin. Home grown is usually received by the manufacturer sawn " through and through "—that is, as a sliced-up log—so that the boards are irregularly shaped and have sloping edges. There is little attempt at grading, and it is seldom possible to obtain supplies which have a moisture content of less than sixty per cent. It can be imagined that the industry has come to regard home grown with considerable distaste.

No attempt can be made here to go into a scientific description of the nature of wood, but the chief characteristics which complicate its use in a solid form in manufacturing processes are *first*, the comparatively great variations, even within any one grade, of its physical properties of weight, hardness, strength, elasticity and of its straightness and direction of grain ; *second*, the fact that wood is a hygroscopic material which, even after a drying process, will continue to absorb or lose moisture with variations of the atmospheric conditions in which it is stored. The effects of the variations in its physical properties and grain structure are that on the one hand it is impossible to guarantee that every board of a parcel will be able to be used for any particular purpose and that it is impossible to calculate—except within broad limits—the performance in use of any particular section. This point is of comparatively little importance, as the sections in use in furniture construction are still largely influenced by traditional proportions, and these, having stood the test of time, are adequate in the majority of cases.

The effect of the variation in moisture content is, of course, considerably more serious, as wood expands or shrinks as it absorbs

or loses moisture. The approximate equilibrium of moisture content of wood in normally-heated houses in this country is between 12 and 14 per cent., where moisture content is determined by the following formula :—

$$\text{Percentage} = \frac{\text{original weight} - \text{oven dry weight} \times 100}{\text{oven dry weight}}$$

That is the relation of the weight of the moisture present in the wood to the oven dry weight of the wood. Unfortunately, in this country furniture is subject to a very great variety of atmospheric conditions, and, whereas furniture kept in a continuously heated room may remain between the limits given, furniture in an unheated bedroom in the winter may rise to a considerably greater moisture content. The degree of shrinkage and swelling which is involved with variation in moisture content is very difficult to assess, as different specimens of the same grade of the same timber will react differently according to their particular structure, and the shrinkage of any particular specimen is different in a direction tangential or radial to the log from which it was taken. As an indication of the degree of movement which may be expected, however, the following data supplied by the Forest Products Research Laboratory* are interesting :—

> Home-grown beech, when dried from 20 per cent. to 10 per cent. moisture content, shrinks $\frac{5}{8}$ in. per foot in a tangential direction and $\frac{5}{16}$ in. per foot in a radial direction. Comparable figures for the common species of oak are $\frac{3}{8}$ in. per foot in a tangential and $\frac{1}{4}$ in. per foot in the radial direction.
>
> Shrinkage along the length of the grain is, however, negligible.

It will be appreciated that in the ordinary process of quantity manufacture it is not possible to distinguish between tangentially or radially-cut boards, and that these varying rates of shrinkage must present a considerable problem. It is interesting to note that in the United States the problem is very much simplified. There, the vast majority of furniture produced is destined for centrally-heated houses, where the equilibrium moisture content is between 7 and 10 per cent. The practice there is therefore to dry down to this level and to ensure that the atmospheric conditions in the factories do not permit of any expansion before shipment.

LAMINATED WOOD

Laminated wood is now familiar to everyone in the form of plywood, and it has come to play an increasingly large part in all types of furniture production. Its chief virtues as a production material are :—

(a) its comparatively great and consistent strength in relation to its thickness.

* *A Handbook of Home Grown Timbers.* (*H.M.S.O.*)

(b) its freedom from any considerable variation in dimension with varying moisture contents.
(c) it can be bought in boards, the great majority of which are in standard sizes of considerable width.
(d) its comparatively precise grading.

The only other laminated product which is commonly in use in furniture production is blockboard. Blockboard is made from a core of jointed solid timber faced on either side with one or more veneers. It is used largely where the appearance of solidity is required, and it is thought that thinner plywood would, through its flimsy appearance, adversely affect the marketability of the product.

VENEERS Veneers used in furniture production are usually sliced from boards chosen for their decorative nature and they are received by the furniture manufacturer in bundles of from 20 to 50 leaves of from .6 mm. to .9 mm. thick cut from any one board or flitch. A grading system is applied to veneers made from certain timbers, but others of more highly decorative value are usually bought as individual flitches. Oak and mahogany, the two chief furniture woods, are usually supplied in veneer form in square-edged bundles, but the bundles themselves vary widely in length and width, generally within similar limits to imported lumber. Other decorative veneers such as walnut and the various burrs and curls are usually received in irregularly-shaped flitches, and the conversion of these is, of course, more complicated and wasteful.

METHODS AND EQUIPMENT Turning to the process of furniture manufacture, we find that while methods and equipment vary in the different types of firms, it is possible to describe in broad terms the fundamentals of the essential processes.

The initial operation must be seasoning of the solid timber, except in the few cases where manufacturers buy all their stock kiln-dried from the timber trade. Seasoning is carried out either "naturally" or by kilning or by a combination of both methods. In natural drying, the boards are piled—usually in the open—in stacks built with spacing sticks so as to permit the free circulation of air, upon which the drying depends. The disadvantages of this method are the time it takes—at least a year for each inch in thickness—and the consequent locking-up of capital in stocks and yard space, and the fact that in this country it is seldom possible to dry down to the necessary moisture content in the open; a further period of storage in heated premises is required. The modern drying kiln, on the other hand, can dry with precision to any required moisture content with no more and frequently less

harmful effects to the timber than air drying causes. The kiln is essentially a chamber, equipped with fans for forced draught, in which both temperature and humidity can be accurately controlled. In this chamber the wood to be seasoned is placed in a pile similar to the open-air drying stack, and by controlling temperature and humidity the maximum safe rate of drying can be obtained. A very great deal of experimental work has been carried out in kiln drying by the Forest Products Research Laboratory—a unit of the Department of Scientific and Industrial Research—and, as a result of this work, the laboratory has published for all commercial timbers schedules of temperatures and humidities to be worked to when kilning at various moisture contents. Kiln drying has the additional advantage that it effectively kills any of the wood beetles or their grubs with which the timber may be infested, a matter of great importance in view of the increased depredations of the Lyctus beetle during recent years.

It is sometimes found desirable to combine both methods when the stock to be dried is either exceptionally wet or not of a consistent moisture content. A preliminary few months' seasoning in the open air quickly brings down excessively high moisture and tends to equalise the moisture content of the parcel.

During the past twenty years many new drying methods have been devised, in attempts to accelerate the process, but none has so far been able to better the performance of a kiln of the type described above. At the moment, a great deal of experimental work is being carried out in the application of high-frequency dialectric heating to the drying of timber. Inasmuch as this high-frequency technique results in generating heat in the wettest part of the wood—usually the centre—it appears to have possibilities, but up to now no generally practical commercial process has been evolved. The fundamental difficulty in all timber-drying problems is of moving physically a certain amount of water through the cellular structure of the timber without harming it, and it appears that there are limits to the speed with which this process can safely be carried out.

After seasoning, the next main process in the manufacture of furniture is the breaking down of the dry material into the sizes required, and the machining of those sizes to the shapes and detail required for assembly. The initial breaking down of the boards is carried out by saws, which rip to width and cross-cut to length. The modern rip-saw, known as the straight line edger, is a circular saw to which boards are fed by driven chain and rollers, and it is capable of operating at feed speeds up to 150 f.p.m. Developments of this machine have been evolved which carry two or more saws and enable a number of widths to be ripped at one passage. In cross-cutting, on the other hand, the circular saw is made to travel

through the stationary material to cut it off to length. A roller bench is usually provided with length stops and the actual travel of the saw, at one time operated manually, is now frequently effected by pneumatic or hydraulic mechanism. When shaped parts are required, the initial breaking down of the boards is carried out by band saws.

WOODWORKING MACHINERY

When we turn to the machining to final shape of furniture parts, we find a very great variety of machines devised generally for particular operations, but not necessarily unduly specialised in their application. In the average woodworking machine shop there will be between 15 and 30 different types of machines, but they are all developments either of revolving heads, to which are attached one or more cutters, or of drills, or of saws, or combinations of these tools. These machines, in general terms, will flatten, plane to thickness, mould to section, tenon, mortise, mitre, tongue, groove, dovetail, or bore. One of the simplest and one from which many others have sprung is the single spindle moulder. It comprises a vertical spindle which protrudes through a square worktable and on which cutters are mounted either between collars, or on a block, or in certain types of machine through a slot or slots in the head of the spindle itself. The material to be worked is passed manually along the table and past the cutters.

Developments of this simple machine are many and various, but time does not permit of more than a brief description of two of the more complicated applications of the revolving cutter head principle. The " four-cutter," so called because it had originally four such heads, now usually carries five or six of them. It is designed to plane and mould all four sides of wood fed through it : the feed is usually by power-driven rollers and the heads are mounted horizontally above and below the stock and vertically at either side. The heads are, of course, adjustable to the limits of the machine to accommodate varying sized material. It will be appreciated that the use of a machine of this type involves a considerable setting time, and it is therefore only found in plants which are big enough to give it reasonable length of runs. The feed speeds of normal furniture hardwoods may vary from thirty to seventy feet per minute, but, when cutting softwoods or work where a high degree of finish is not required, feed speeds as high as 300 feet per minute have been recorded.

The modern double tenon machine gives some further idea of the complexity of modern woodworking machinery. Its purpose is to cut a tenon joint at either end of a piece of wood, and, as the mortise-and-tenon is perhaps the most common furniture joint, it is of great importance in all large shops.

The stock previously machined to the desired section is fed on two parallel chains and is carried through the machine by dogs. The machine has one fixed side and one adjustable for length of stock, and on each side will be found the following cutting heads, all of which can be canted :—*first :* cut-off saws to square the stock to length ; *second :* scoring saws, whose purpose is to score a thin line at the inward limit of the tenon to be cut, to avoid breaking out ; *third :* top and bottom tenon heads, which are cutters mounted on revolving blocks on horizontal spindles ; *fourth :* top and bottom scribing heads, which are cutters mounted on revolving blocks on vertical spindles. This equipment is more or less standard on all modern double tenons, but the latest developments of the machine carry additional heads, amongst them what are known as gaining heads mounted on a horizontal spindle between the two main sides of the machine, whose purpose is to make any cut-outs or grooves which may be required between the tenoned ends of the stock.

Woodworking machines are generally characterised by high spindle speeds, which are now usually obtained by the use of frequency chargers for electric motors coupled direct to the spindles ; 6,000 to 7,000 r.p.m. is now common on moulding machines or four-cutters, while the router machine—which has also been used extensively in profiling light alloys—operates on wood at 18,000 or 24,000 r.p.m. Feed speeds also are high, and much development work has ben carried out in applying mechanical feeding arrangements to a wide variety of machines. High-speed steel has been used for the majority of woodworking cutters for many years, but the recent increase in the use of plywood and synthetic resin glues has created a need for an even harder cutting tool. The use of cemented carbide tips on saws and cutters has, therefore, spread considerably during the past few years, and they are fast becoming a commonplace in the woodworking machine shop.

SANDPAPERING AND VENEERING

A final operation of great importance is sand papering and to carry this out there is a wide variety of machines which are constructed to sand paper stock of almost any shape or size.

Allied to the machining process is the work of the veneering section. Here, veneers have to be selected, cut to length, edged and jointed up to width, and glued to the core stock of plywood or blockboard. It is interesting to note that veneers of no more than .6 mm. thick are now glued together edge to edge in a jointing machine, when making them up to width. Pressing is, of course, the vital point in the laying of the veneer, and the equipment used in the industry varies from the old hand screw press to the modern hydraulic multi-daylight hot press. The great extension in the use

of synthetic resin glues during the past ten years has naturally extended the use of the hot press, as with it curing cycles of from five to ten minutes are common. When operating on these very short pressing times, it is frequently found that the loading and unloading of the press is the limiting factor in output. There are, however, many manufacturers who still use cold glues (either starch or casein) with a single daylight hydraulic or hand press. In this process the load, after pressure has been applied, is held by retaining side clamps and taken from the press for the necessary setting time, which is several hours.

The veneering of shaped or moulded stock is carried out in several different ways, and special presses have been devised where pressure is applied through compressed air operating on a rubber sheet, which moulds itself to the core stock.

Much work has also been done in developing the use of low voltage metal strips for applying heat to shaped work and in applying high frequency heating to this type of operation.

ASSEMBLY OF MACHINED PARTS

The next major process is the assembly of machined parts—the realm of the cabinet maker proper—and this is roughly divisible into three separate operations ; cramping, fitting and finishing. In factories still working on traditional methods, the cabinet maker is generally responsible for the entire process, and he uses only the ordinary hand tools of his trade. He has a good deal of skilled work to do, as most machine shops of the older type do not aspire to real accuracy of dimension and leave difficult work to be cut by hand. It is probable that though assembly on these lines is dying out in all medium-size and large concerns manufacturing for the cheaper end of the market, it will continue for a long time to come in the manufacture of more expensive articles where dependence will continue to be on the hand craftsman.

In large-scale manufacture of machine-made furniture, the process is becoming increasingly one of semi-skilled assembly : the different operations are separated, and in many cases a line assembly technique has been developed. Sub-assembly is carried out in bulk to the greatest possible extent with the aid of jigs and fixtures to ensure correct positioning. Hand-power tools are extensively used and various nailing and tacking machines have been developed for the furniture trade.

Cramping, which is frequently the main assembly operation, is carried out in pneumatic cramps which are made in a variety of designs to suit the article being asembled. The fitting of doors and drawers has been infinitely simplified by accurate machining, and the finishing process is little more than a cleaning up of marks or damage which the article has suffered during assembly after its

bulk sandpapering. In fact, the time has already come, in this class of production, when the cabinet maker can leave at home the majority of his tools.

POLISHING

In the polishing of furniture—the last major production process—materials and methods vary greatly but the separate operations remain the same. First, the base stain is applied, to bring the whole article to the required colour ; then, the filler, to fill the open grain where necessary ; next, a coat of sealer, a material designed to seal in the base stain and serve as a basis for the final coats of polish. After both the sealer and polish coats, a rubbing process is required to cut the coats of material down to a smooth surface. Owing to the variations in the original colours of the pieces of wood in any one article and to their differing reactions, according to the direction of grain and hardness, to the base stain, an additional operation of matching by applying colour where necessary is required to bring the whole article to a reasonably even shade. A final polish usually completes the process.

The main distinction in materials and method is between French polishing—usually carried out entirely by hand with materials of a shellac or spirit base—and cellulose spray polishing where all the main materials are applied by compressed air spray guns. The latter method has come to be almost universally used in quantity production and has lent itself to development by means of conveyor systems to the stage where little or no manual handling is needed from the beginning to the end of the process. Indeed, the possibility of applying the main coats completely automatically by means of electronically controlled spray guns had been demonstrated by 1939.

In an effort to improve the cellulose polishing process, a new lacquer has been introduced containing a very much higher proportion of solids, which can only be spread when the material is kept in specially heated containers. Another development which promises to be of importance in the future is the production of polish materials based upon the synthetic resins.

This rapid and very superficial survey of the main materials and processes of the industry will, it is hoped, serve as a background to a commentary on the particular difficulties which are experienced in the quantity production of furniture, difficulties which arise through the nature of the raw materials.

DEVELOPMENT IN ORGANISATION

The development in the organisation of large-scale production has followed closely the generally well established lines of the engineering industry. Once a product is designed, detailed working drawings and instructions are made out for the constituent parts and in the

detailing of these parts the greatest possible use is made of standards, which are established for dimensions, joints, etc. The machining of the detailed parts and the major processes of assembly and polishing are planned for the various operations to be carried out, and jigs, templates, fixtures and tools are designed and made. The labour cost for each of the planned operations is estimated by the Time Study Department, and standards are set for material and labour costs, all this of course, to the end that when production begins it should flow to the time-table drawn up for it and at a cost not exceeding the estimates ; the day when production flows through the planned processes exactly to schedule and at just the estimated cost will be a red letter day in the furniture industry.

The industry is, of course, subject to most of the influences which cause performance to fall short of plans in, say, the engineering industry, but it has also to cope with the difficulties inherent in woodworking. The first of these is the fact that machined parts are likely to shrink or swell to an unknown extent and possibly also to warp between the machining and assembly operations. The best cure for this difficulty is, of course, the perfect seasoning of the lumber and the maintenance of atmospheric conditions in the storerooms of the factory at a level to prevent further movement. Obviously, perfection can seldom be obtained in this respect, but, even if it could, there is the further complication that movement may take place in the timber after delivery to the customer. The only way in which we can do anything to overcome this difficulty is in the design of furniture, and it will be found that the constructional methods for the quantity-produced furniture have deviated considerably from the old hand methods, not only to facilitate production but also having in mind this difficulty. For instance, whilst it is perfectly possible to machine a mortise-and-tenon joint so that the resulting framework will have a flush surface, it is impossible to guarantee that a flush joint will remain flush in different atmospheric conditions. It has therefore been increasingly the practice to design and construct furniture to avoid flush joints. This is only an example, but it is an indication of the influence which the Production Engineer is having on the design of furniture, in an effort to make it capable of real quantity production.

A considerable amount of development work has also been carried out in the use of laminated structural members and moulded plywood shapes. At present these materials are too costly to be incorporated in expensive furniture and they have not come widely into use, but being comparatively immune from shrinkage and swelling they have production advantages.

CONVERSION PROBLEMS

As soon as we come to actual production, the immediately obvious problem is that raised by the way in which lumber is bought ; that is, in boards of varying length and width. It is not usually graded for quality sufficiently accurately to enable us to say that the whole of any particular parcel will be suitable for any one particular job. The influence of the varied sizes of the boards makes itself felt in the initial breaking-out through straight line edgers and crosscuts, inasmuch as it is almost impossible to foretell what the product of a particular footage to the mill will be. The obvious cure for the first part of this problem is the pre-sorting of material and it has been found that, provided the total volume of timber being handled is sufficient, it is quite possible to sort the boards to length on their arrival to, say, 6 in. multiples so that a particular length can be ordered for cutting into any particular combinations of parts required. This sorting to length, however, obviously entails very considerable storage space and the holding of large stocks to enable decent-size workings to be made from the selected lengths. It has been found impracticable, usually, to carry pre-sorting the stage further—which seems desirable—of sorting also to width. If, then, a particular load sent to the sawmill is of selected lengths, it will only mean that the crosscutting can be planned—subject to quality—but that the ripping to width must still involve selection on the part of the sawyer.

This selection is of vital importance, because throughout timber conversion there is the conflict between the need for producing the sizes required at a particular time, and the need for conserving material. (It might be noted in this regard that solid lumber represents in value approximately 15 to 20 per cent. of the total cost of the average piece of cabinet furniture.) Selection at the saw then leaves the conservation of material entirely to the skill of the operator and very considerably reduces the output of the saws. It has been found possible to overcome these difficulties by putting in an operation, before ripping to width, in which the boards are passed through a specialised operator whose only duty is to measure the various widths, and to mark the boards in code for the widths into which they can be ripped most economically. Much ingenuity has been expended in devising special marking rods which enable this operation to be carried out very efficiently. It is important to note, however, that apart from the variations in width, any such marking has also to take into account any bad shape in the boards which might prevent their being ripped to the widths which could theoretically be cut from them.

There are two other points of importance regarding the state of the lumber as received at the mill. The boards are cut nominally to a certain thickness, say, 1 in., but in practically all parcels there

will be a certain proportion of boards which are substantially below this in thickness. This is due either to eccentricity in drying or to bad sawing in the lumber mill, but it must be noted that provision must be made for extracting any such scant boards at the earliest possible stage, to prevent both the expenditure of labour on material bound to be rejected and to avoid the reduction through rejects in the size of the working. There is also the question of quality. As has been said above, a further degree of selection is often required within the grade bought, when certain face parts are being manufactured. To a degree this problem too can be overcome by pre-sorting and pre-selection of the material required for any particular job, but it has always to be borne in mind that there are very real limits to the amount of such work which can be carried out. Where it cannot be done, of course, selection once more becomes a part of the breaking-down operation, with its consequent reduction in output.

These remarks on the conversion of lumber take no account of the present difficulties with home-grown material cut through and through. It can be imagined that with it the problems are very much exaggerated and comparatively little can be done to eliminate selection at the saws.

Very similar difficulties arise in the conversion of bundles of veneer, but with this material the greatest possible attention has to be paid to selection for quality and figure, and it is seldom that pre-sorting and grading can be carried to sufficient lengths to permit of the conversion of veneer on any but a selective basis. It must be noted, too, that many veneered parts have to be prepared in matched pairs or sets, and the fully-machined veneered parts have to be issued for assembly in their pairs or sets.

The conversion of plywood is relatively free from these complications, when the market permits of purchases of the grade required. Where it does not, pre-sorting or selection on the saws is necessary. Complications can arise, however, in manufacture from variations in the thickness of plywood. The normal tolerances of the plywood manufactured are plus 10 minus 5 per cent. of the nominal thickness, and though it is generally reasonably consistent, conditions at present—when material from many different manufacturers and countries of origin are being used—are difficult.

A practice becoming increasingly important before the war, and revived to some extent by the Timber Control during the last two years, has been the importation of dimension or cut-size stock; that is to say, the purchase of solid or plywood cut by the lumber manufacturer to the sizes required for manufacture. It will be obvious that there are limitations to the degree to which cut-size stock can safely be bought, as frequent variations in design are needed in the trade. There is also the risk in lumber that stock

may warp or twist after cutting and become useless for the purpose for which it was ordered. To the extent to which it can be used, however, it certainly simplifies very greatly the production processes and their planning.

DETAILED MACHINING

When we come to consider the detailed machining of furniture parts, the greatest problem which we encounter is the varying "machinability" of different timbers and of different pieces of the same timber. Thicknessing, surfacing and moulding is carried out by machines of various types, all of which use the revolving cutter in one form or another. The difficulty arises principally in the liability of certain timbers to "tear-outs," that is, instead of a clean cut shearing through the fibres, portions of the timber are torn out along the line of the fibres. The most difficult timbers to deal with in this respect are those with interlocking grain, typified by the stripy effects seen on some timbers, and curly grain, which may arise as an eccentricity in many types of timber. In interlocking grains, the actual direction of the grain (that is, the direction in which the wood fibres lie) changes with each year of growth of the tree, and certain boards cut from such timber show a complete change in direction of grain every inch or so of their width. In curly grain, the fibres form irregular curves or undulations switchback fashion along the board.

Much experimental work has been carried out by the Forest Products Research Laboratory and commercial users to achieve a reasonably standard performance of such timbers through the machines. Attention has been paid particularly to cutting speeds and feed speeds, and to the cutting angles of the cutters. Some users have tried reversing the direction of rotation of the cutters to cut with, instead of against, the direction of feed. By research into these points, a good deal of information has been obtained and some progress made which has enabled the general standard of machining to be improved, but the stage has not yet been reached when it can be said that a consistent result can be guaranteed for any particular parcel of timber. Rejects are still being made and it is still impossible to forecast accurately what their extent will be. This obviously makes the task of completing a given number of parts extremely difficult and affects the planning of the factory as a whole.

PLANNING PRODUCTION

Linked with this work on the technical aspects of wood-machining are developments in methods and organisation. In the traditional type of shop, each machine operator grinds his own cutters to the required profile and then mounts them as required on blocks. It is becoming increasingly common now for a central cutter shop to be set up

where all straight and profile grinding is carried out by specialists and the cutters mounted on blocks ready for issue to the machines. This development has brought great advantages in that profiles are standardised, machine-setting times are greatly reduced, and the quality of the grinding is generally improved, with consequent saving in cutter steel. Whilst this type of specialist cutter shop is a comparatively recent development, a central saw-sharpening shop has for a long while been a commonplace. The other big change which has come over the modern machine shop is the virtual disappearance of the wooden rule, for many years the only means of measurement in the furniture industry. Gauges, templates and jigs have not only increased accuracy of work but have also speeded up production. Nowadays thickness gauges are, for instance, commonly made with a tolerance of plus or minus .010 in., whereas in the days of the wooden rule a thirty-secondth of an inch was certainly the finest measurement used, and generally work was carried out to the nearest sixteenth of an inch.

The full benefit of such developments as these can only be obtained when they are allied with an efficient control organisation whose functions include the sequencing of work to minimise setting, machine loading and the servicing of machines with the necessary equipment, jigs, etc. With the fast feed speeds, possible with modern machinery, it is only with first-class organisation that the percentage of setting time to running time can be kept within reasonable limits.

All these steps outlined above, or other ways of overcoming the fundamental problems, are being taken in the effort to enable production to be planned and carried out with accuracy. Where successful, they have an immediate effect, as has already been suggested, on the assembly of furniture. There is little, perhaps, that can be added in regard to this branch of the industry, except to emphasise that here again jigs and fixtures, mechanical cramps, and power tools are tending to make the operation purely routine and immeasurably faster than was possible under the old methods of production. The nature of wood does not, of course, change, and hold-ups and rejects are experienced through the idiosyncrasies of particular pieces of wood which may split or warp, so that however far we progress it appears probable that furniture assembly can never be quite so sure a matter as is assembly of metal products.

In the polishing of furniture, once more the chief problems which arise in establishing line production are due to the nature of the material. The direction of grain and the natural porosity of the wood and veneer differ greatly and the action of stain varies accordingly. This calls for a considerable degree of matching if the polishing process is to maintain its quality. Insofar as the degree of matching required cannot be forecast, production planning

is difficult, and there has been a tendency to try and overcome the difficulty by the use of pigmented materials which gloss over the irregularities of colour, but with a loss in quality as the actual timber itself tends to become obscured.

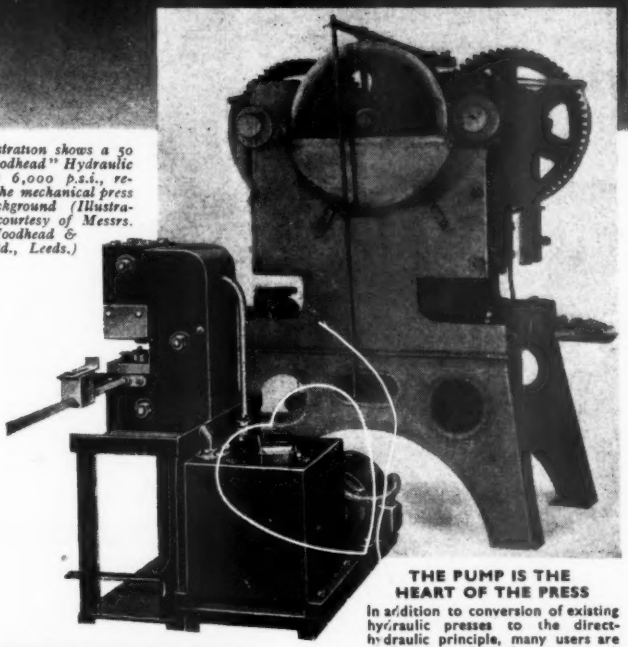
In conclusion, it is felt that the imperfections and inadequacies of this paper will be all too obvious to any who have a knowledge of the furniture industry. The purely technical problems of drying, sawing, machining, bending and glueing wood have all attracted a considerable amount of attention during the past thirty years, and there is a reasonably adequate amount of published information on them. Little, however, has been published on the particular problems which arise when the attempt is made to carry out quantity production on modern lines with wood, with all its vagaries, as the principal raw material, and it is hoped that these remarks will have been of interest to Production Engineers. At least, it will perhaps cause them to return with relief to their more normal raw materials of precise specifications and known performance.

Notes

Notes

REPLACEMENT OF MECHANICAL PRESSES BY

DIRECT-HYDRAULIC SYSTEM



The illustration shows a 50 ton "Woodhead" Hydraulic Press at 6,000 p.s.i., replacing the mechanical press in the background (Illustration by courtesy of Messrs. Jonas Woodhead & Sons Ltd., Leeds.)

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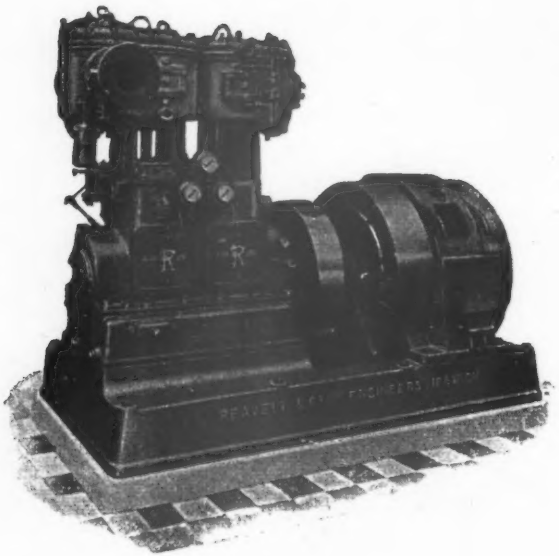

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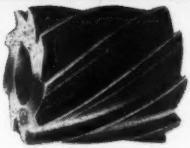
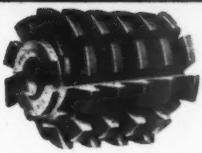
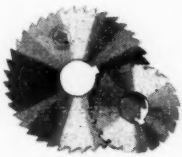


MILLING CUTTERS



HOBS & FORM CUTTERS

REAMERS & DRILLS



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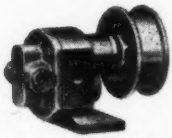
DRILL CHUCKS



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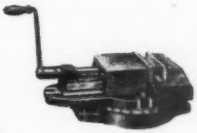

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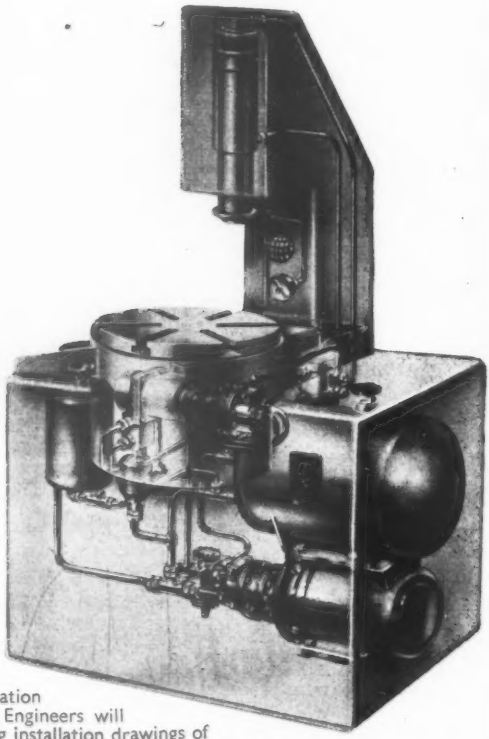

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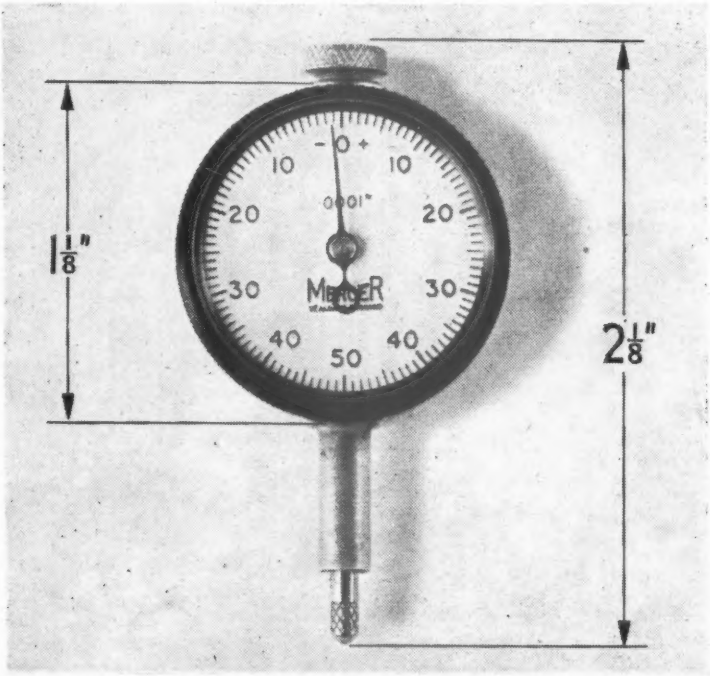

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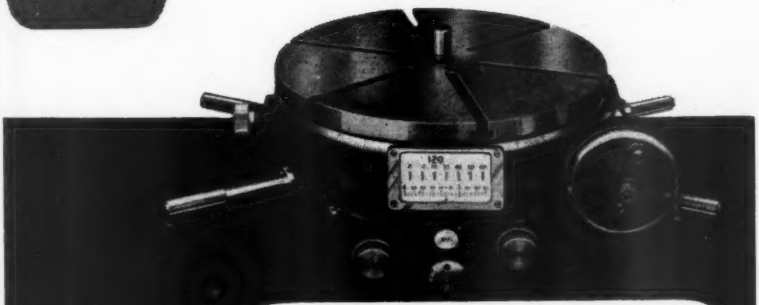

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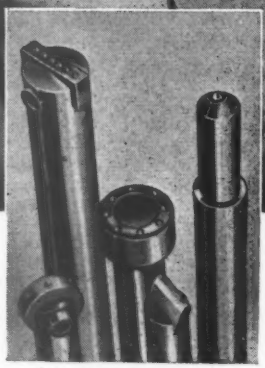

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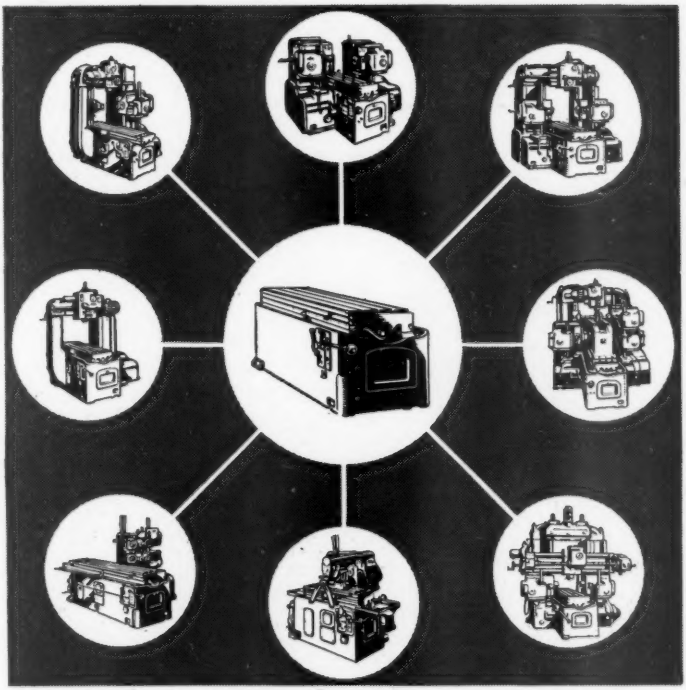

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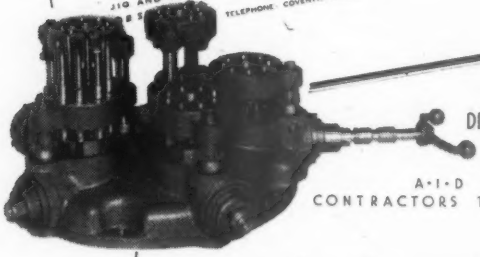

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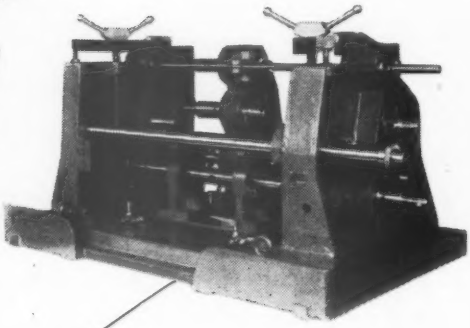

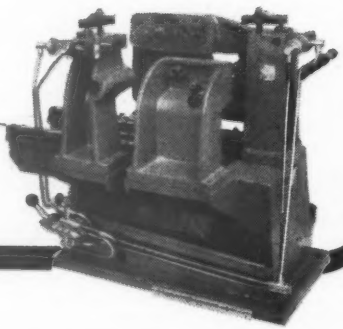

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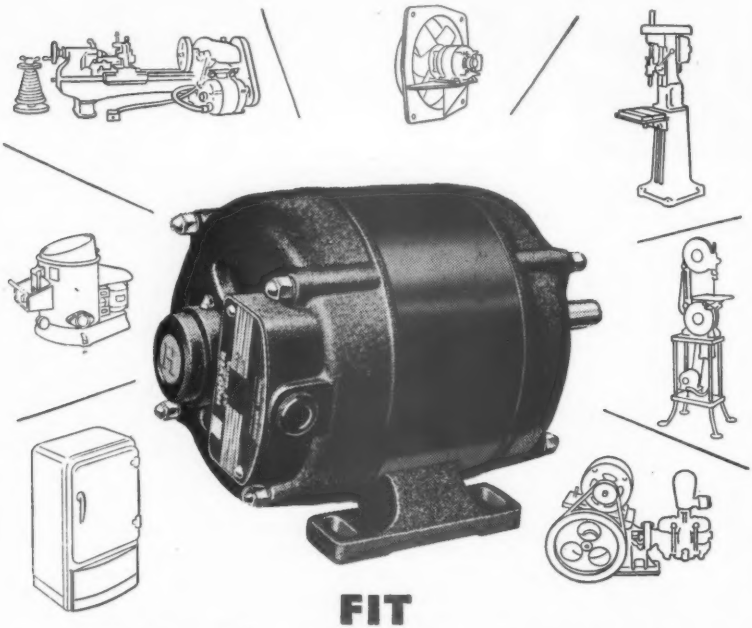

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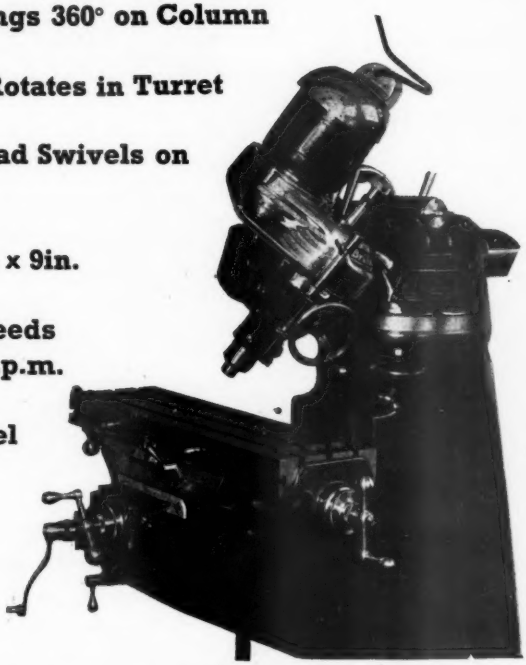

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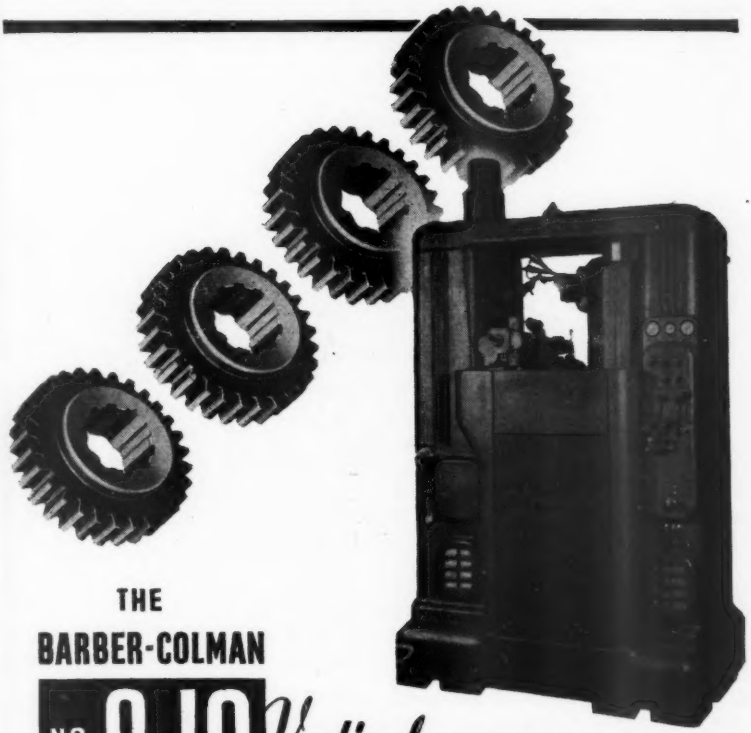

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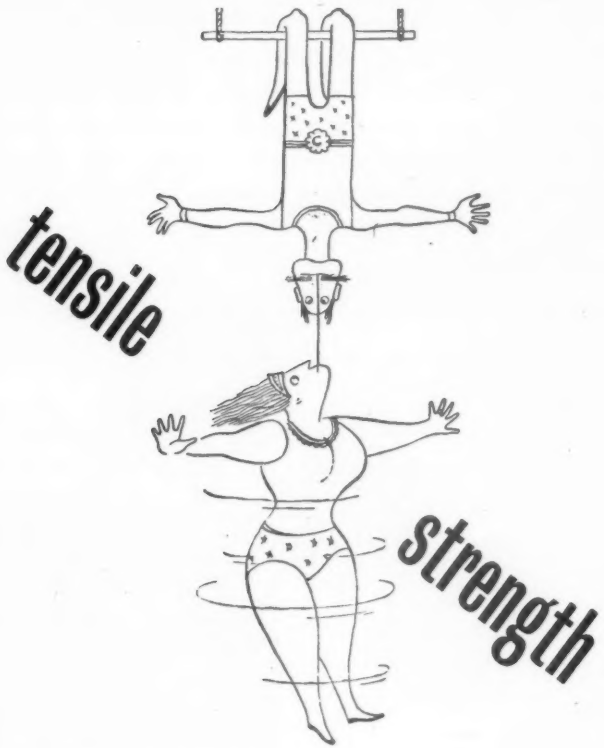

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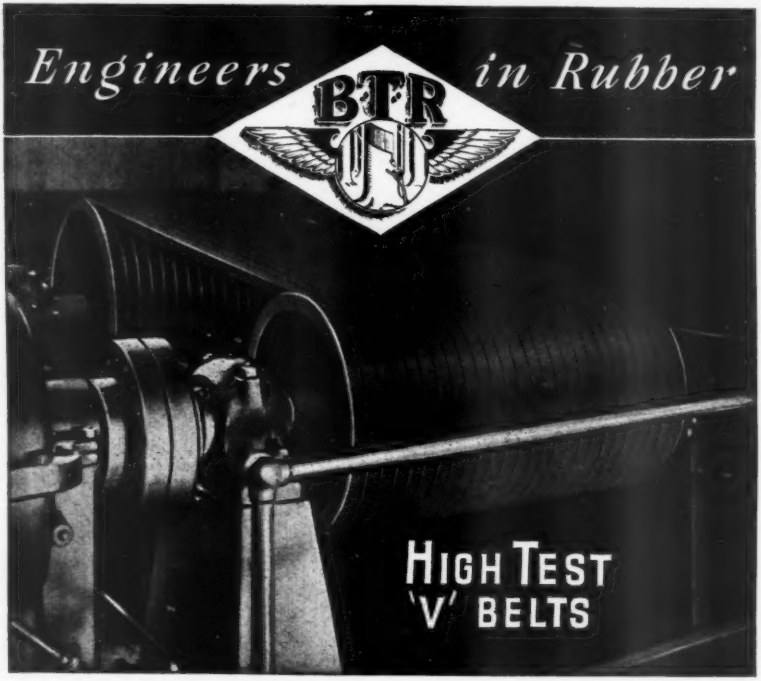

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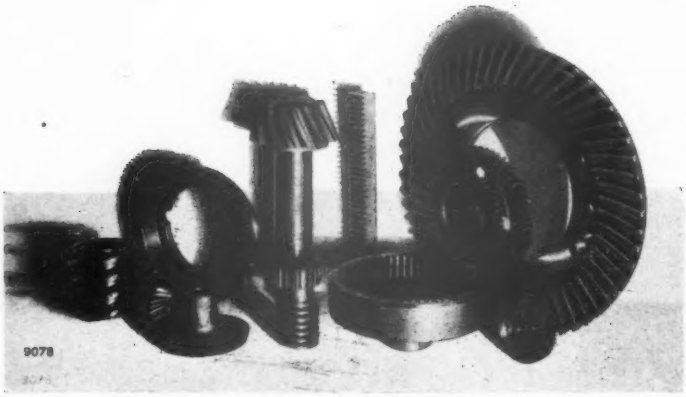

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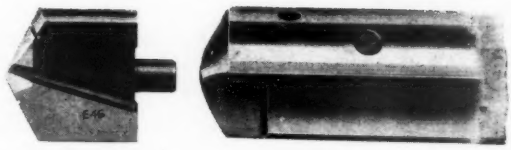

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THE HERBERT
STRAIGHT FLUTE DRILL

Much better than the ordinary spiral flute drill for drilling deep holes in steel.

Detachable cutter is of high speed steel. The body, a few thousandths smaller than the cutter, has two straight flutes.

Oil is carried to the cutters through two holes drilled in the body.

SIZES MADE—$\frac{13}{16}$" to $4\frac{1}{4}$".

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FULL DETAILS FROM S. T. DEPT. RED LANE WORKS.
'PHONE: 89221 (10 LINES).

TRY ALFRED HERBERT LTD · COVENTRY

You deserve something better than soda water . . .

In the handbook of a well-known firm making cutting tools, we observe with a sigh that "soda water" is still mentioned precisely as it was 30 years ago!

No production engineer today would ever dream of figuring on speeds, feeds and production times which were current 30 years back, so much have machines tools and materials altered meanwhile, Modern machining methods require modern coolants, of which COOLEDGE is the most versatile, no matter the duty demanded! COOLEDGE not only efficiently carries away cutting heat, but lubricates exceptionally well, due to its generous fat content, thus preserving the tool edge and giving fine finish to the job. Due to its coarse oil/water construction, the lubricating film provided by COOLEDGE emulsion has enhanced strength so extending its useful range of application to tooling hitherto given over to straight oils. That represents a true economy.

Then, with dilutions which range from 1:10 to 1:75 COOLEDGE shows adaptability to tooling operations on most metals and merits its claim to be 'a machine-shop service in itself.'

Ask for our latest brochure 'Cutting Fluids'—it's free on request.

COOLEDGE

Water Soluble Cutting Oil

ALSO INCLUDED IN THE WATER SOLUBLE RANGE ARE :—
IRONEDGE · ALUMEDGE · FILEDGE · CLEAREDGE

Cutting Fluids by FLETCHER MILLER LTD

HEAD OFFICE & WORKS
HYDE Nr. MANCHESTER ENGLAND
Phone: Hyde 781 (5 lines) Grams: Emulsion, Hyde

SOUTHERN WORKS
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MIDLAND WORKS
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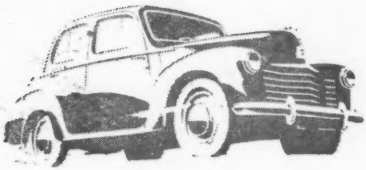
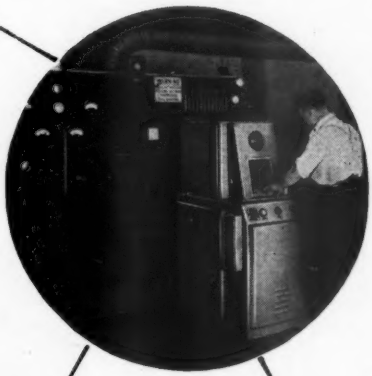
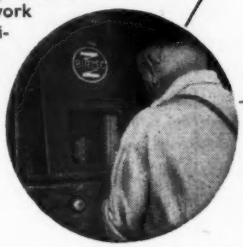
BIRLEC and the new Vauxhalls

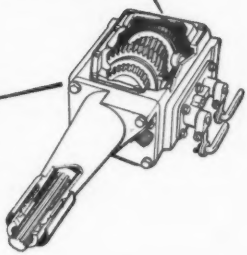


The synchro-mesh gear box of the new Vauxhall cars employs a sliding sleeve with internal splines which take the brunt of the synchronising torque. For the local hardening of these splines, after final machining and without distortion of the sleeve, Vauxhall have installed this Birlec induction heating unit. This is just one of the tricky production heat treatment jobs handled regularly by specialised Birlec induction equipment.

For scale-free, distortionless, localised hardening as an automatic repetition process, Birlec induction heating is often the answer. Versatile units, installed direct in the production line, can be adapted for a range of generally similar work and can pay handsome dividends in quicker production, reduced grinding, cleaner finish and fewer rejects.







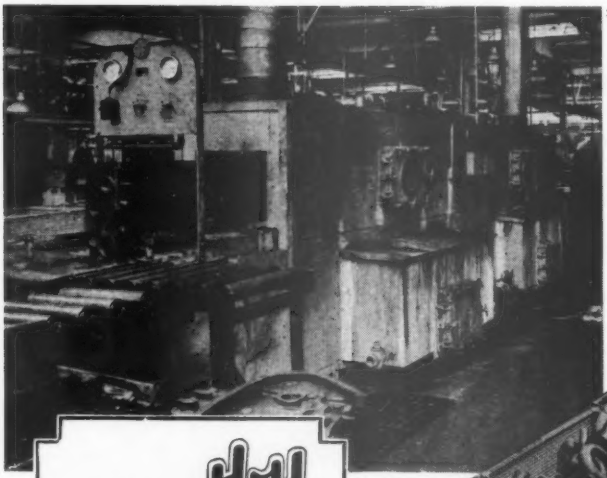
BIRLEC LTD · ERDINGTON · BIRMINGHAM 24

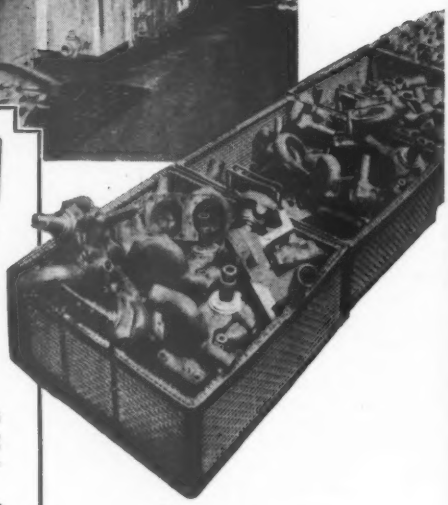
In Australia : Birlec Ltd., Sydney, N.S.W. *In Sweden* : Birlec Elektrougnar AB, Stockholm

HEAT TREATMENT BIRLEC & MELTING FURNACES

BM/B19C

Each cleaning problem studied individually





Bratby

INDUSTRIAL CLEANING MACHINES

This illustration shows a machine cleaning crank cases in the production line.

It is equally capable of cleaning small parts in baskets.

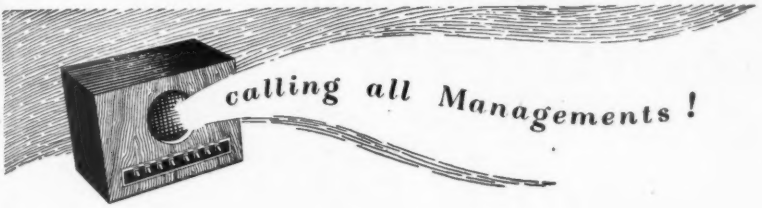
Photographs by courtesy of "Machinery"

Sole Agents for Great Britain :

GEO. H. HALES MACHINE TOOL CO. LTD., Victor House, 1, Baker St., LONDON, W.1

Designed and manufactured by :

BRATBY & HINCHLIFFE LTD., SANDFORD STREET, ANCOATS, MANCHESTER 4



FUEL USAGE ANALYSIS

—*a first step to lower prices*

IT IS surprising to find—as the Ministry of Fuel and Power is constantly finding—that what could be called the "fuel component" in the costs of production of very similar products can vary enormously between one maker and another.

Why does one firm so often use twice as much fuel as another? Such variation is surely too great to be accounted for by differences in the process or in quantity and quality of product.

"Management Interest" is the secret

It is almost always found that efficiency starts at the top. If Management is actively interested in its usage of fuel, heat and power—if Management is constantly asking questions and listening sympathetically to its engineers' suggestions—its influence is infectious. From the Chairman's office all the way down to the coal yard, people begin to sit up and pay attention.

"Fuel Usage Analysis"—what it is and how to start it

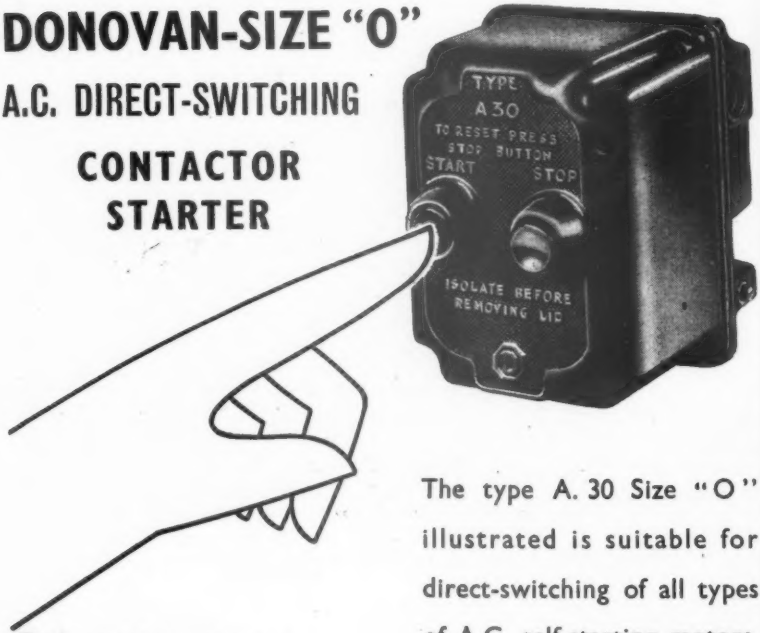
It is not enough to know the total amount of fuel, heat and power used every day or week or month. More details should be sought and many more questions asked. How much does each department and each process use? Who is too cold and who is too warm? Would it be helpful to instal steam-meters and thermometers and other instruments—and who should be responsible for their regular calibration and maintenance?

Once Management starts asking itself questions, it will begin to achieve results. Some pertinent questions are available. Later advertisements in this series will direct you to them.

Issued by the Ministry of Fuel and Power

DONOVAN-SIZE "O"

A.C. DIRECT-SWITCHING CONTACTOR STARTER



- *Magnetically-operated with undervoltage Release & 3 O.C.R.*
- *Silver Faced Contacts*
- *Suitable for direct control from Start & Stop pushbuttons in lid*
- *Solenoid construction gives magnet quick & Positive action in opening & closing*

The type A. 30 Size "O" illustrated is suitable for direct-switching of all types of A.C. self-starting motors. It will appeal to Machine Tool Makers who require a starter of compact design and reliability in operation.

DONOVANS

THE DONOVAN ELECTRICAL Co LTD
BIRMINGHAM 9
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ELECTRICAL ENGINEERS AND STOCKHOLDERS
GRAMS - "DONOVAN, BIRMINGHAM"

NEW, REBUILT *and* SECONDHAND

PLANT *and* MACHINERY

Remember **WARDS** *might have it*

SPECIAL OFFERS

If you are interested in plant and machinery for a particular trade or purpose it is good policy to keep in touch with WARDS who will advise you promptly whenever special offers of such equipment become available.

Our holdings of plant and machinery are listed in the 'Albion Machinery Catalogue' — write for the current issue today.

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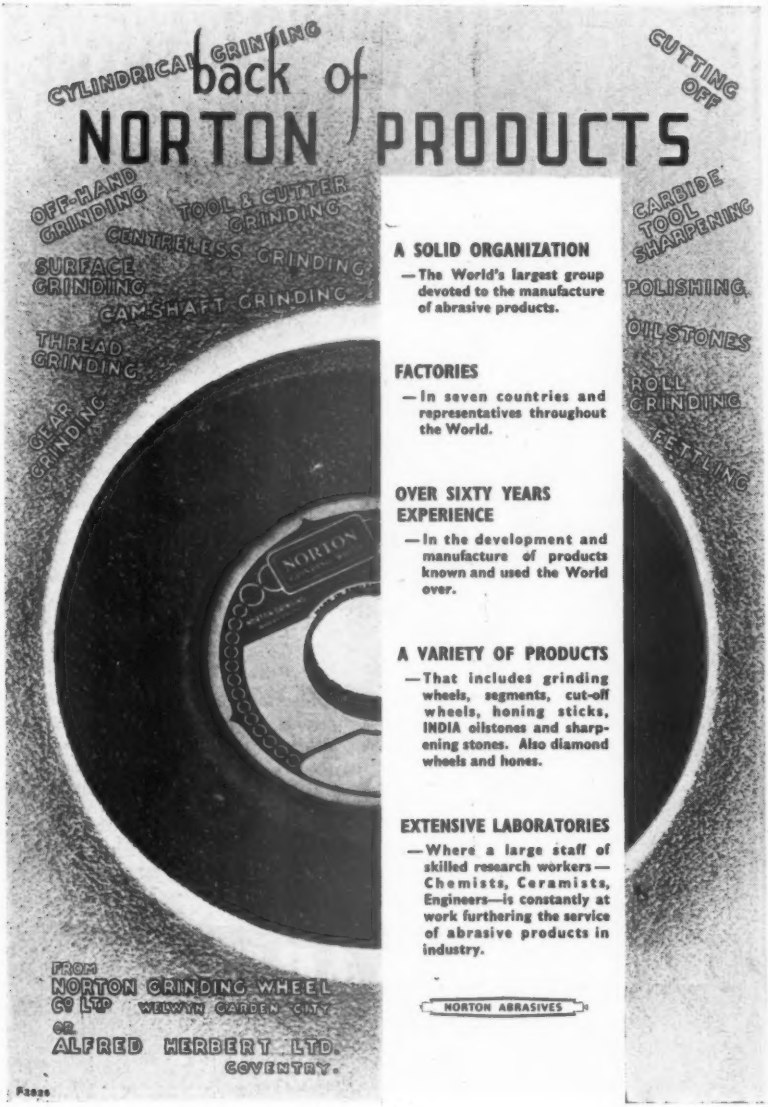
GLASGOW OFFICE: 18/24 FORE STREET, SCOTSTOUN, W.4
SOUTH WALES OFFICE: Giants' Wharf BRITON FERRY, Glam.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NORTON PRODUCTS
CUTTING OFF
OFF-HAND GRINDING
TOOL & CUTTER GRINDING
CENTRELESS GRINDING
SURFACE GRINDING
CAMSHAFT GRINDING
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A SOLID ORGANIZATION
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— In seven countries and representatives throughout the World.
OVER SIXTY YEARS EXPERIENCE
— In the development and manufacture of products known and used the World over.
A VARIETY OF PRODUCTS
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— Where a large staff of skilled research workers — Chemists, Ceramists, Engineers — is constantly at work furthering the service of abrasive products in industry.
NORTON ABRASIVES
FROM NORTON GRINDING WHEEL Co LTD WELWYN GARDEN CITY
OR ALFRED HERBERT LTD. COVENTRY.
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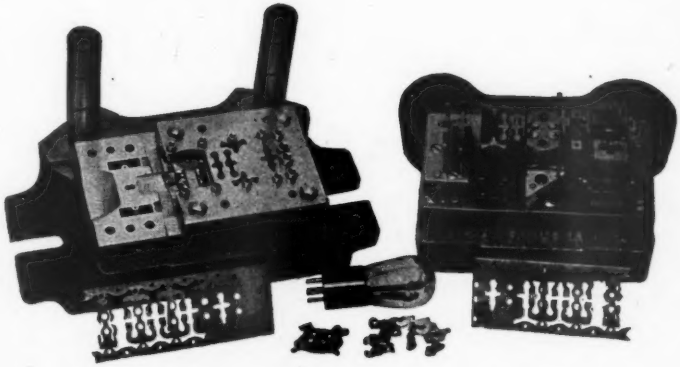
LARGE OR SMALL



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ARNOTT & HARRISON LTD.

(Member of the Gauge & Tool Makers Association)

22, Hythe Road
WILLESDEN

Telephone: LADbroke **3484-5-6**

ARNOTT HARRISON WILLESDEN

Thread Grinding and Measurement

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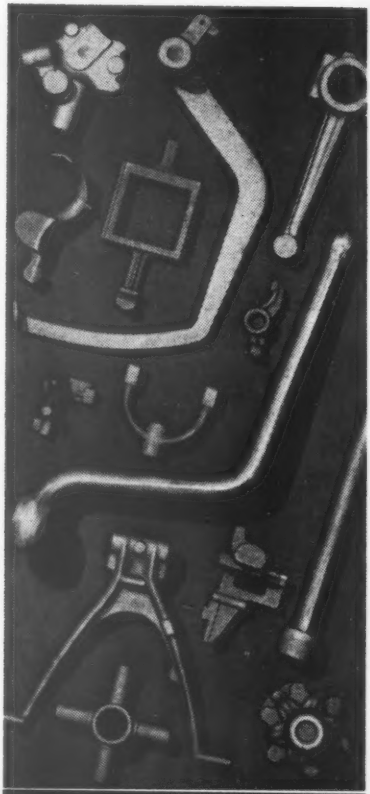
Parker Street, Kingsway, London, W.C.2



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CLEAN AND ACCURATE
IN ALLOY AND CARBON STEELS

Made by

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Telegrams: Midforge

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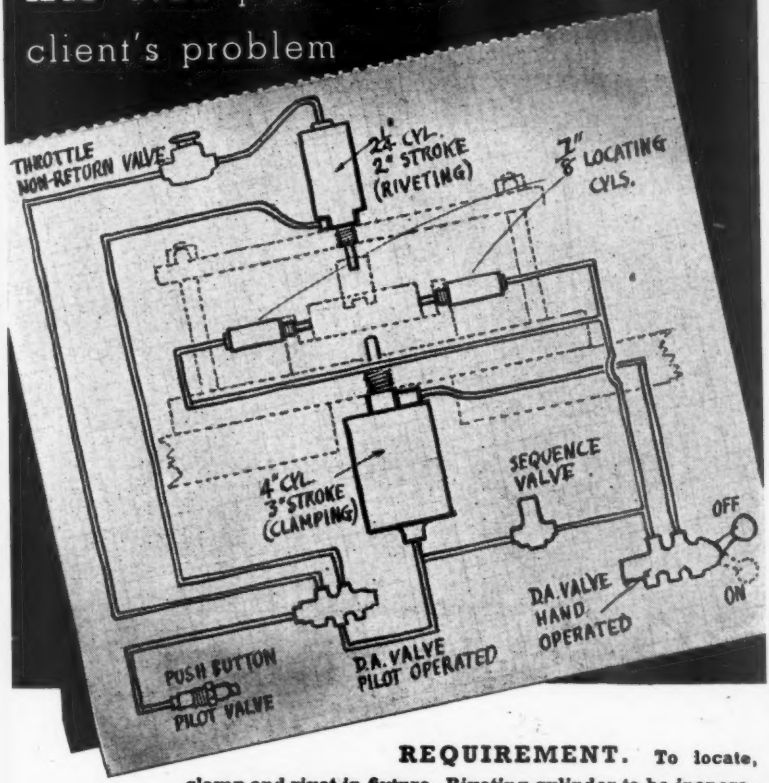
Air aids production — a Maxam client's problem



REQUIREMENT. **To locate, clamp and rivet in fixture. Riveting cylinder to be inoperative if component is not clamped and operator's right hand not on valve. Operator's left hand to control riveting operation — thereby engaging both hands as a safety measure.**

FUNCTION. **Hand-operated valve controls locating and clamping with sequence. Push-button pilot-valve operates pilot-controlled valve and riveting cylinder.**

The possibilities of **MAXAM SPECIAL SERVICE TOOLS** are practically unlimited. If you have a problem, send it to :—

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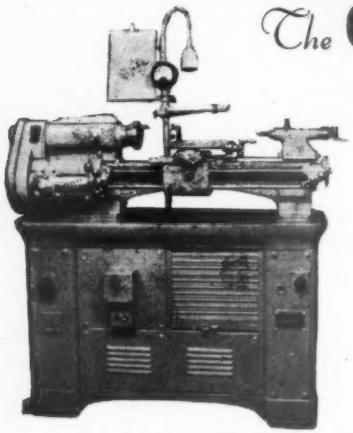

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3½" S.S. & S.C. LATHE

TYPES S800 & S800M (METRIC)

STEPLESS spindle speed changes with r.p.m. indicator.
Feed changes by dial. Magazine for screw-cutting.
Standard threads cut without use of change gears.
Metric, B.A. and other threads cut by using enclosed change gears.
High speed spindle in precision adjustable plain bearings.
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All-electric spindle drive, gearless except for the back gears.
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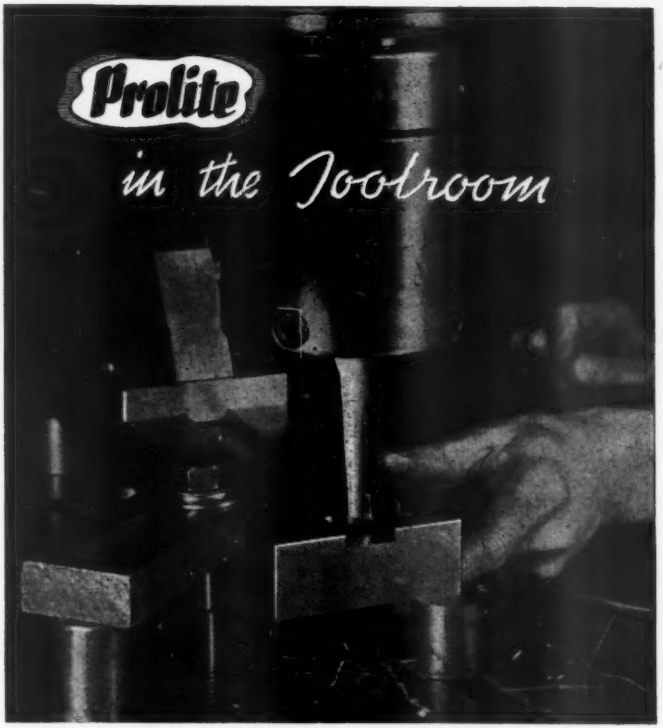

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Technical Representatives are always available for consultation and advice.

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(A subsidiary company of Murex Ltd., Rainham, Essex)

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THE ABWOOD TOOL & ENGINEERING CO. LTD. Princes Road, Dartford, Kent. Tel.: Dartford 2258/5

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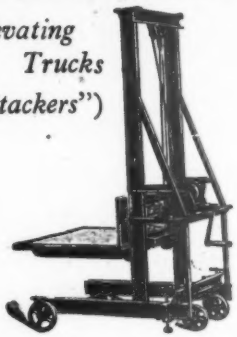

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Just two models selected rom our current catalogue which illustrates almost 200 models of trucks, trolleys, lifting trucks and other labour-saving devices specially designed to meet your needs. *A postcard will bring you a copy.* Write TODAY to:

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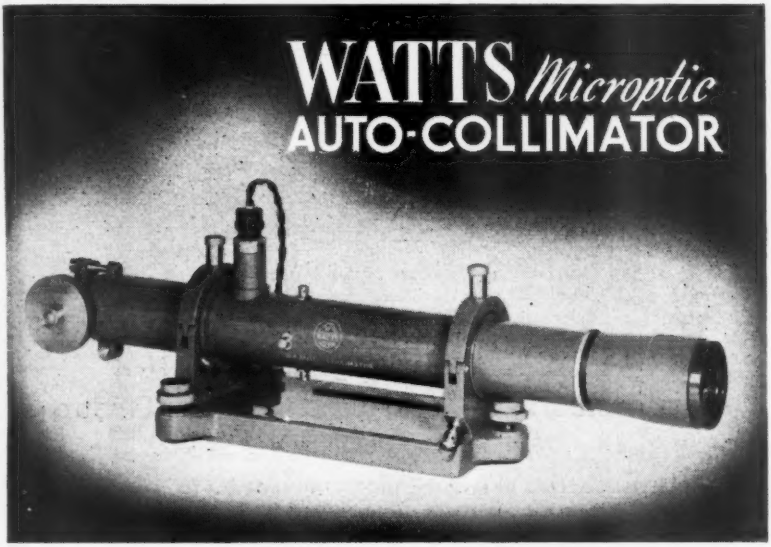

A precision instrument with direct reading to 0.5 second over a range of 10 minutes. With Watts Microptic Auto-Collimator, used in conjunction with an optical reflector, small angular and linear displacements can be measured more conveniently than by conventional mechanical methods, and to an accuracy of a fraction of a second of arc.

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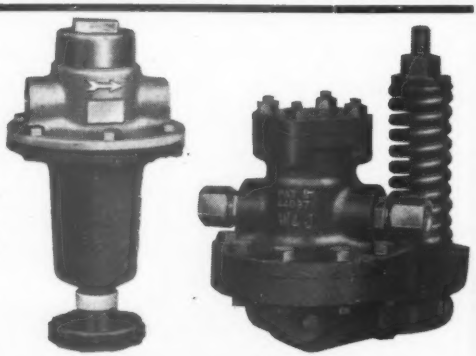
No glands, no sticking or chattering, readily accessible. Well-made and perfectly balanced these valves give excellent service under all conditions.

Please state purpose of valve when ordering.

Guaranteed for 12 months.



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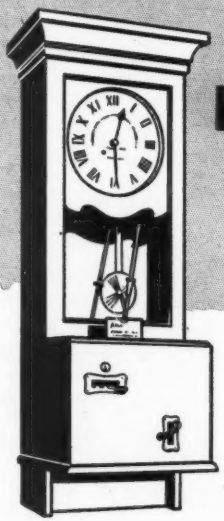

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The Gledhill-Brook Company was intimate with the early problems associated with the design and production of time recording machines, and was first in producing efficient electric impulse recorders with accurate time-keeping free from dependence on electric frequency or external influence. Wages and cost methods have a time basis — that is where we are concerned to help.

A large number of time recording models is now available covering most of the known needs for wages and labour cost control. One of industry's immediate needs is the reduction of waste—the waste of time that costs money.

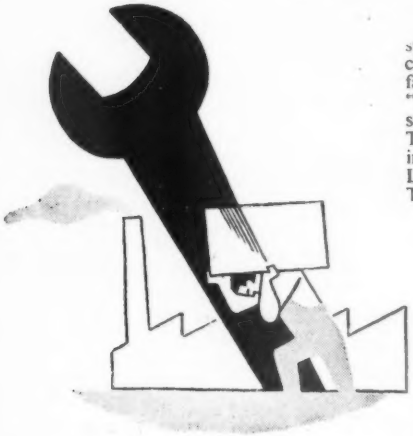
GLEDHILL-BROOK

TIME RECORDERS

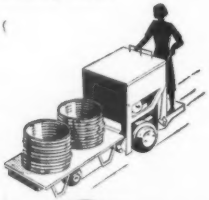
GLEDHILL-BROOK TIME RECORDERS LIMITED

20 EMPIRE WORKS HUDDERSFIELD

Is there a spanner in *your* works?



Outmoded short-haulage can be a real spanner in the works—wasting manpower, causing bottlenecks and congestion on the factory floor. The remedy is electrical—"Electricar" works trucks—the modern labour-saving, cost-cutting system of works haulage. To find out how they can speed-up production in your factory write to Crompton Parkinson Ltd., Crompton House, Aldwych, W.C.2. Telephone CHAncery 3333.



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(Tensile Strength 45 tons per sq. in.)

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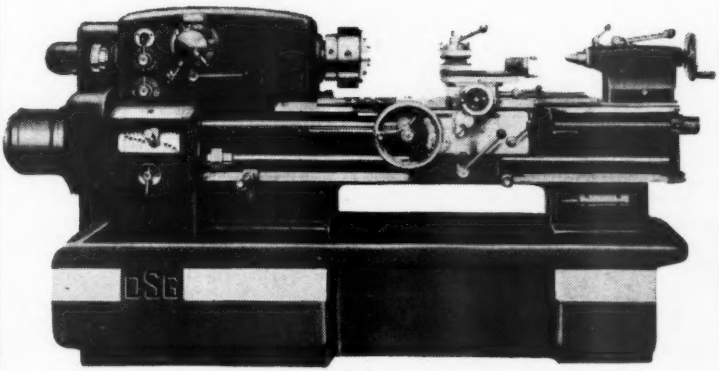
For High Class Production or Toolroom Work

TYPE 13



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from our New Range 13″ to 30″ Swing

Flanged Vee Rope Motor Drive
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Middle Bearing to Spindle
Final Drive to Spindle by Vee Ropes
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KEIGHLEY ENGLAND

YOU'LL NOT GRUMBLE AT THESE, JOE . . .

Old Joe's critical, he's been expected to make his mark without just the right punches. Now he's got a precision job with perfectly uniform, centrally located characters. The new clear-view bevel helps him to get accurate positioning. In their Priority punches, Pryors combine all these features.

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MARKING DEVICES

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THE INSTRUMENTS that reproduce sound and sight—radio sets, radiograms, gramophones and television sets—owe a great deal to zinc alloy die casting. This pick-up arm and its head* are good examples of the process as an ingenious designer can use it.

Why the parts are zinc alloy die cast

The forepart of the arm is hollow and carefully balanced by the solid metal at the other end so that the needle touches the record with exactly the right pressure. This not only reduces friction but improves reproduction. Zinc alloy pressure die casting enables the dimensional accuracy and stability demanded by such precise balance to be repeated quickly and economically in casting after casting.

Like so many other zinc alloy components, the arm and head are chromium plated: a fact which explains why any number of zinc alloy die castings go through life unhonoured and unsung because unrecognized!

Other sound-reproduction uses

Zinc alloy die castings also play a large part in record changing mechanisms, radio and television chassis, cabinet parts, sound boxes and many other kindred components.

*Photograph reproduced by courtesy of Collaro Ltd.

Some facts about zinc alloy die casting

Speed is the essence of the die casting process—the shortest distance between raw material and finished product. Zinc alloys are the most widely used metals for die casting because they ensure:

STRENGTH: Good mechanical properties for stressed components.

ACCURACY: Castings can be made practically to finished dimensions and need little or no machining.

STABILITY: Close tolerances are maintained throughout the life of the casting.

Hence the widespread war-time use of zinc alloy die casting for fuses, gun sights, periscopes, tank carburettors, etc.

British Standard 1004

Alloys conforming to B.S.1004 should be specified where strength, accuracy and stability are essential.

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Enquiries about the uses of zinc alloy die casting are welcome. Publications and a list of members will be sent on request.

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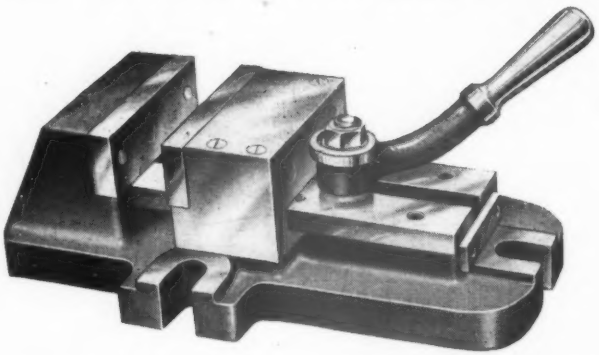

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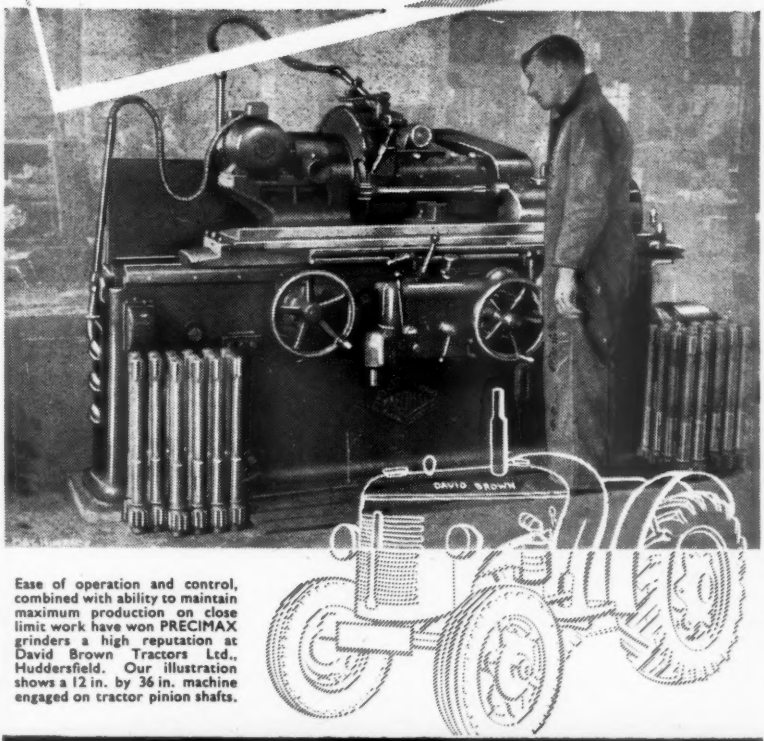

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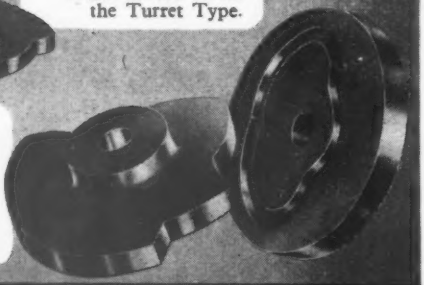

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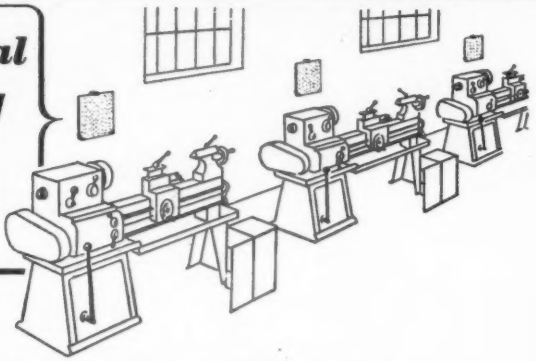

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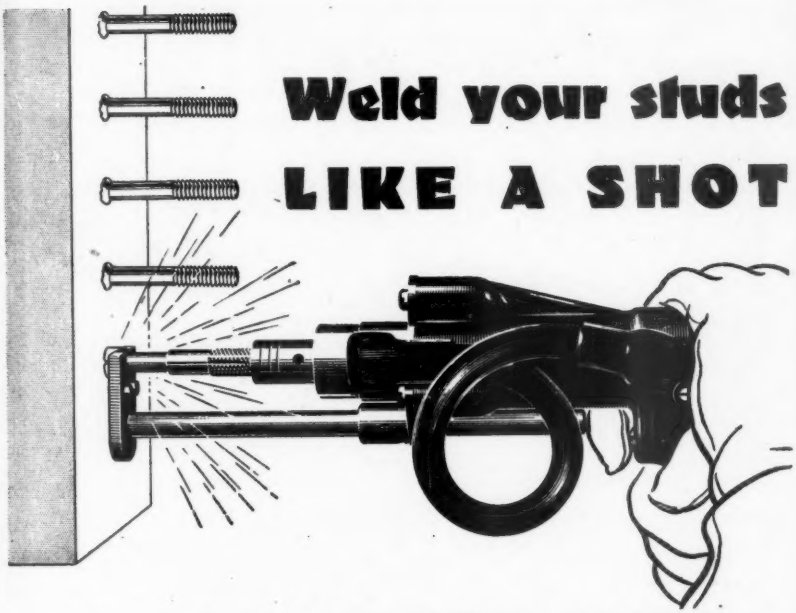

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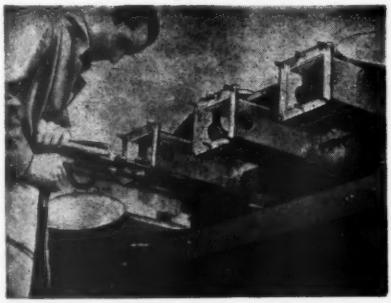

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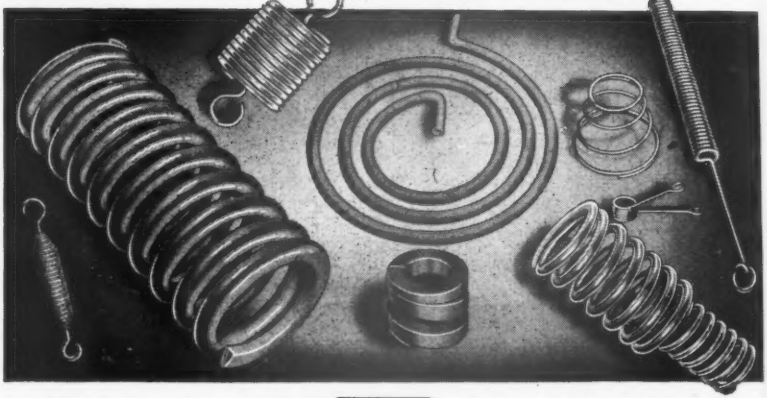

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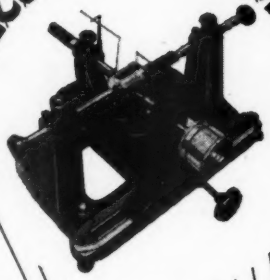

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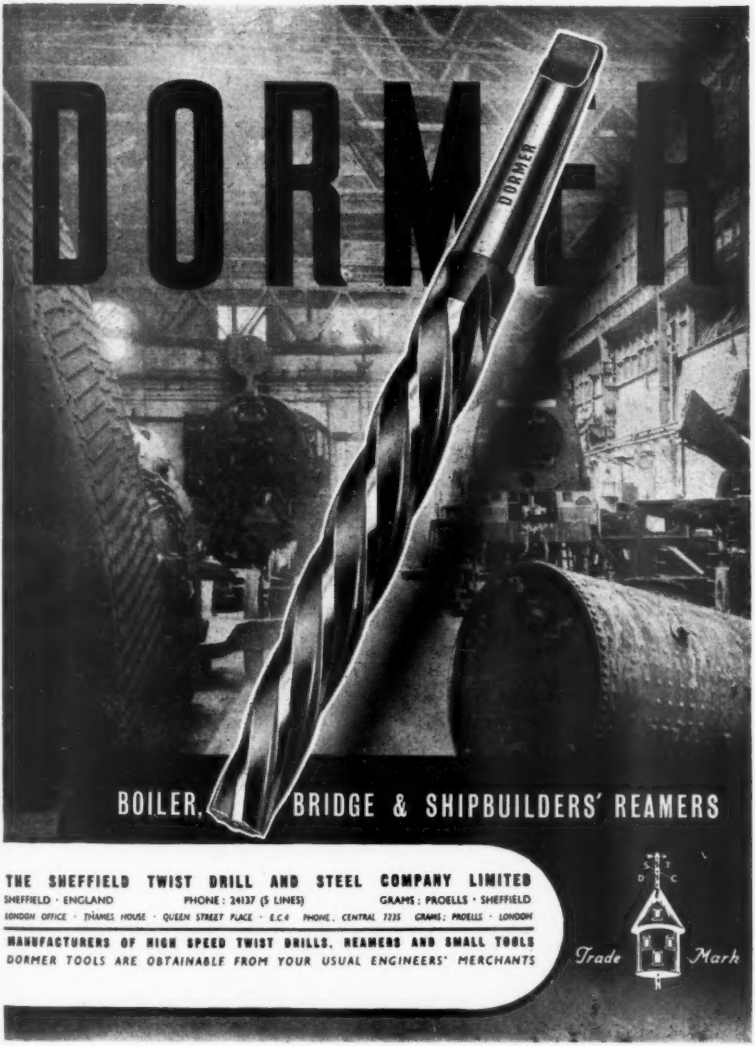
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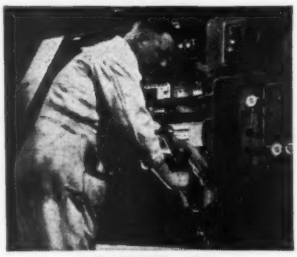
Learn more about the advantages of Wickman auto-setting. Write today to the Wickman Technical Publications Department for full details of Wickman Multi-Spindle Automatics.



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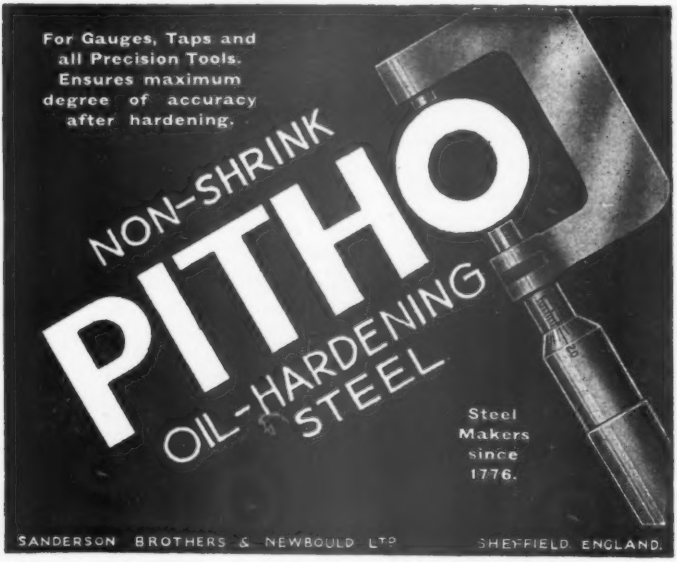
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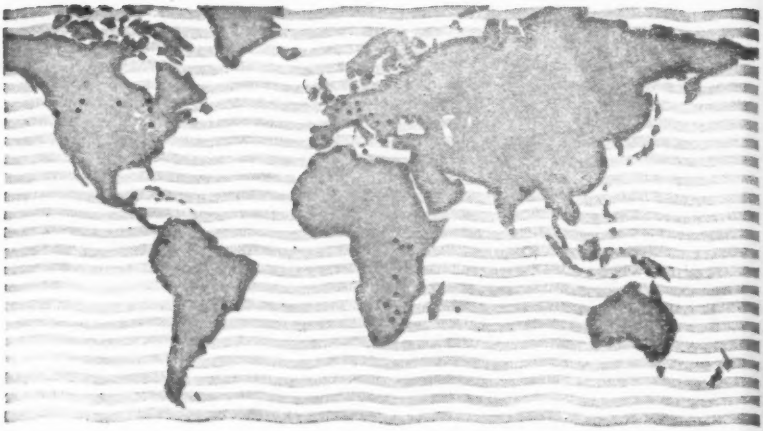

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